In this Issue: The Scoop-Wheel Pumping Plant at Schellingwoude, Holland.—Curved Masonry Dams in New South Wales.—Impending Changes in the British Railway System.—A Steel Arch Design for the St. Lawrence Bridge at Quebec.

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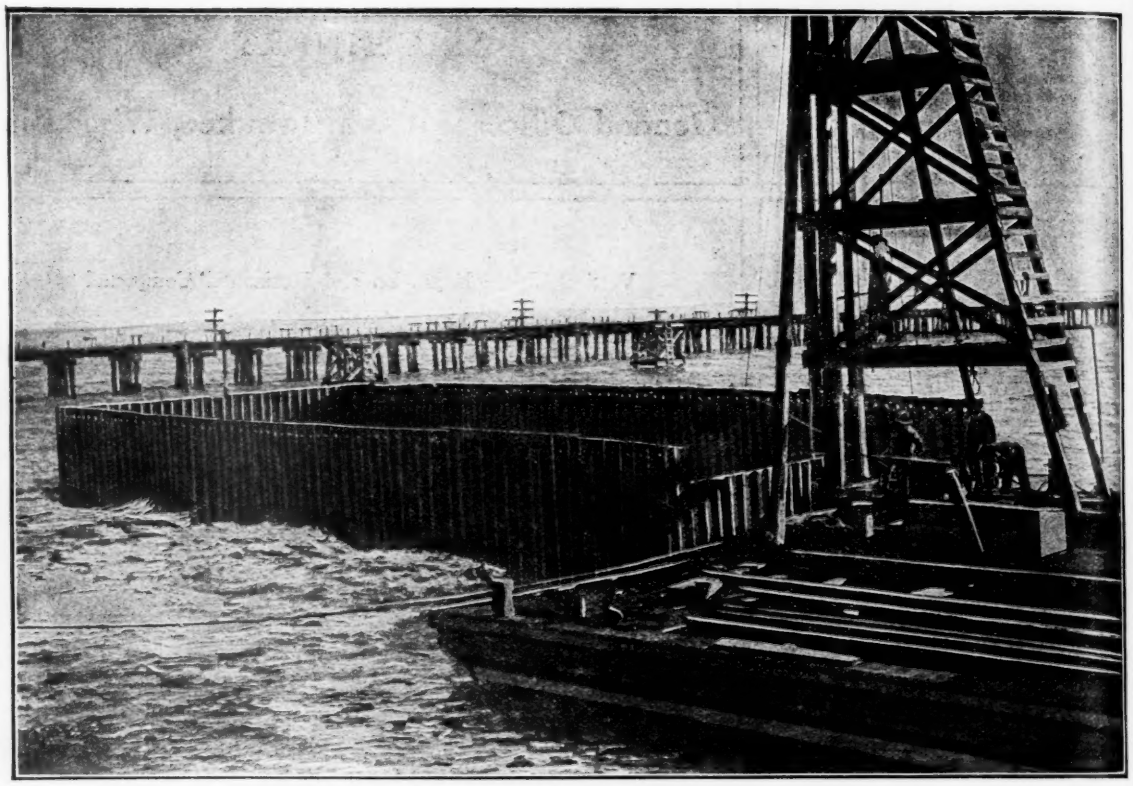

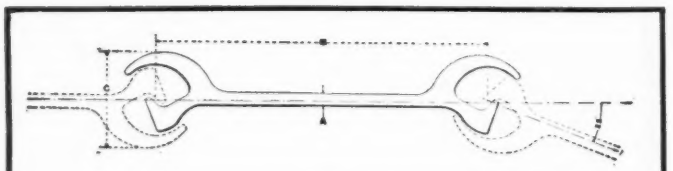

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ENGINEERING NEWS

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An 1,800-Ft. Steel Arch as a Quebec Bridge Project.

A remarkable design for a long-span bridge is shown by the three drawings herewith. It represents a project for a steel voussoir arch to cross the St. Lawrence River at the site of the collapsed Quebec Bridge. While it is only a paper project up to the present, its boldness may engage the reader's attention. The designer is Mr. Charles Worthington, M. Am. Soc. C. E.

This design grew out of a conviction that steel arch construction is adaptable to much longer spans than the largest existing arch spans.* Coupled therewith was the belief that the serious difficulties of secondary stresses, imperfect joint connections, etc., which affect a cantilever bridge of long span, would be completely absent from the arch. These difficulties were somewhat familiar to the designer because he had worked out a Quebec Bridge design for a large bridge company at the time of the first bidding, about ten years ago.

To test these views, the working out of a detailed design was undertaken, and naturally the Quebec Bridge was chosen as the specific case, since it is the most interesting of the now pending problems in bridge design. The drawings show the result in its general features.† In the course of the work the designer came to the conclusion that long-span arch construction not only is feasible practically, but also will compare well in point of cost with cantilever or suspension bridge construction. He therefore believes that the construction shown is the preferable type of bridge for very long spans, provided suitable abutments are available.

As the piers of the Quebec Bridge do not offer direct opportunity for thrust abutments, it was necessary to devise means for carrying the enormous thrust of the arch back to the bluffs, 500 to 800 ft. back of the piers. A suitable means was found in great concrete struts below ground, extending from the piers back to the bluffs. These struts are designed of a cross-section of 1,960 ft. each, being 98 ft. wide by 20 ft. deep.

The most formidable element of the arch problem, erection, is solved in Mr. Worthington's design by an expedient as bold as the whole idea of constructing an 1,800-ft. arch. He proposes to string suspension cables longitudinally over the site, hang the individual voussoirs from these, and then lower the entire aggregation of arch elements to bearing.

*Upper Niagara arch bridge, 840 ft. The proposed Hell Gate arch bridge has a span of 1,000 ft. Both these are two-hinged braced arches.

†We understand that patents have been applied for on several features of the design.

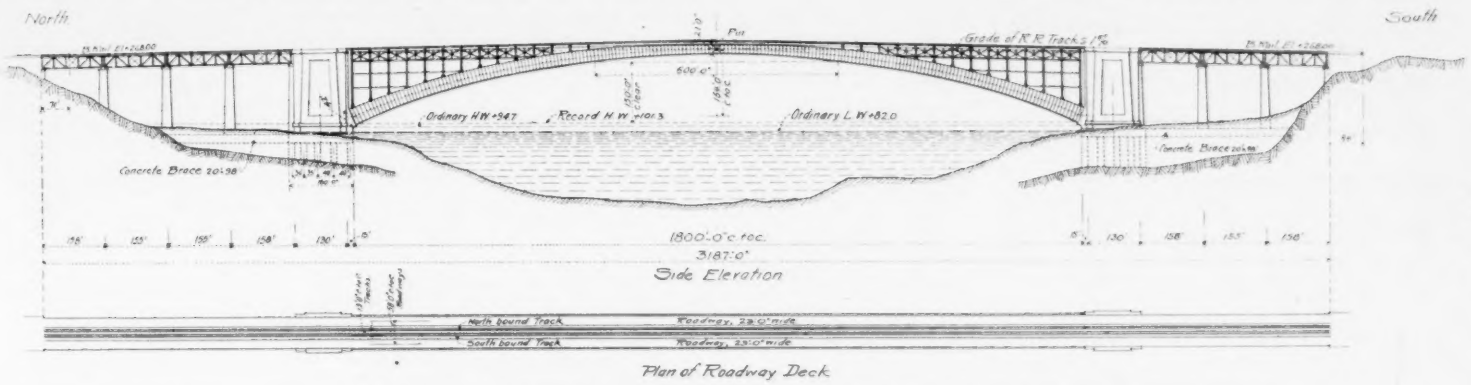


FIG. 1. GENERAL ELEVATION OF 1,800-FT. STEEL ARCH DESIGNED AS A PROJECT FOR THE QUEBEC BRIDGE.

The arch itself has fixed ends and a central hinge. It consists of four parallel ribs, each of hollow rectangular section, built up of plates and angles, with angle bracing connecting the four. Each rib is 21 ft. deep at the crown and 42 ft. deep at the skewbacks, by 9 ft. wide. It is made in separate voussoirs about 9 ft. long each, having abutting faces planed to full bearing. The abutting edging angles of the voussoirs are intended to be riveted together through the outstanding legs, but these rivets carry no stress.

The design was analyzed by the elastic method, for a loading probably close to that adopted by the present Quebec Bridge Board.

The following memorandum from the designer states the essentials of his project more definitely:

GENERAL FEATURES.—The design consists of a steel voussoir arch, essentially the same as the ordinary voussoir arch of masonry, having all the advantages of that old and tried form of bridge. The voussoirs are constructed of nickel-steel plates and angles built up as shown in the drawings, internally braced, and faced to bear one against another, so that the loads are transmitted all the way to the bed rock of the river banks as direct compression, in steel or concrete, without the intervention of rivets anywhere and with a minimum of changes of direction on the way.

The material of the ribs is thick, and is entirely exposed for easy painting all over, inside and out, with no parts buried or partly buried in masonry as is the case with the anchorage of a cantilever or suspension bridge, and with no elaborate joints of eyebar heads and other members all packed in close to each other in a manner to preclude the possibility of proper painting.

All important rivets are shop-driven, and have short grip; while field-rivets are shown connecting the voussoirs one to another, these are merely for the purpose of making a tight joint, and carry no stress.

The size and weight of the voussoirs is such that they may be easily handled and transported by the usual methods.

THRUST BRACES.—To take the thrust of the arch, there are provided braces of concrete extending from the arch piers back to the bed rock, placed below ground, where they will not be affected in length by atmospheric temperature changes.

ERECTION.—Erection is to be accomplished by stringing cables over each rib and suspending therefrom the voussoirs, one by one, beginning at the center, until practically all are thus supported, excepting only a short length out from each pier which may be erected on falsework or by means of backstays to the main piers.

The bracing between the ribs is, like the ribs themselves, also constructed in sections, of the same length as the voussoirs. The purpose of this is that while the voussoirs are hanging loosely from the suspension cables, the transverse bracing may be connected up, so that when finally lowered the ribs will be completely braced from end to end.

It is proposed also to provide the voussoirs with interlocks or guides, so that when they are gradually lowered from the position of loosely hanging to that of bearing one upon another, the face of each voussoir will come to a full and certain bearing against the face of the next voussoir.

Each hanger supporting a voussoir is to be adjustable in length, as by a sand cylinder or a turnbuckle of special construction, so that the voussoirs can be gradually lowered to a bearing.

LOADING, ETC.—The railway floor was designed for Cooper's E 50 loading.

The ribs are designed for a total moving load (including impact) of 11,000 lbs. per lin. ft.

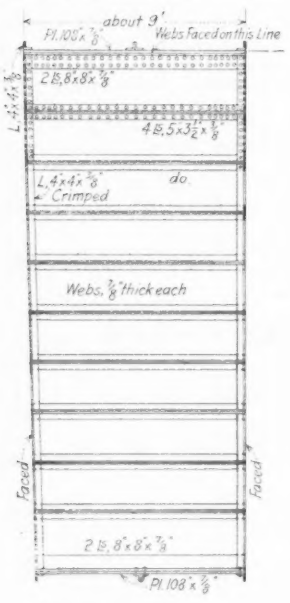
The dead-load is divided as follows at center of span:

	Lbs. per lin. ft.
Two railway tracks—	
Ties, rails, etc.	1,340
Stringers and floor beams	1,760
	3,100
Two roadway floors—	
Deck and stringers	2,300
Floor beams	1,000
	3,300
Bracing	2,100
Total except ribs	8,500

The ribs vary in net cross-section from 27 sq. ft. at the crown to 53 sq. ft. at the skewbacks. The total weight of the ribs and rib-bracing is about 22,500 tons. The total dead-load for the 1,800-ft. span is about 36,000 tons.

The actual dead-load at the various points of the span is determined by the curve of the neutral axis of the ribs. Ordinarily the curve of the neutral axis would be determined by the actual minimum loads of the construction, but in the case of the Quebec Bridge the shape is practically determined by the clearance requirements over the river channel and the necessity for keeping the height of tracks as low as possible. The curve selected, referred to an origin at the point where it would become vertical, which point is $a = 2{,}018.992$ ft. laterally distant from and $b = 2{,}511.595$ ft. vertically below the crown, has the equation

$$y = \frac{b}{a}\,[2\sqrt{a\,x} - x];$$

this equation gives the curve from springing to crown, and the other

Side Elevation of One Voussoir.

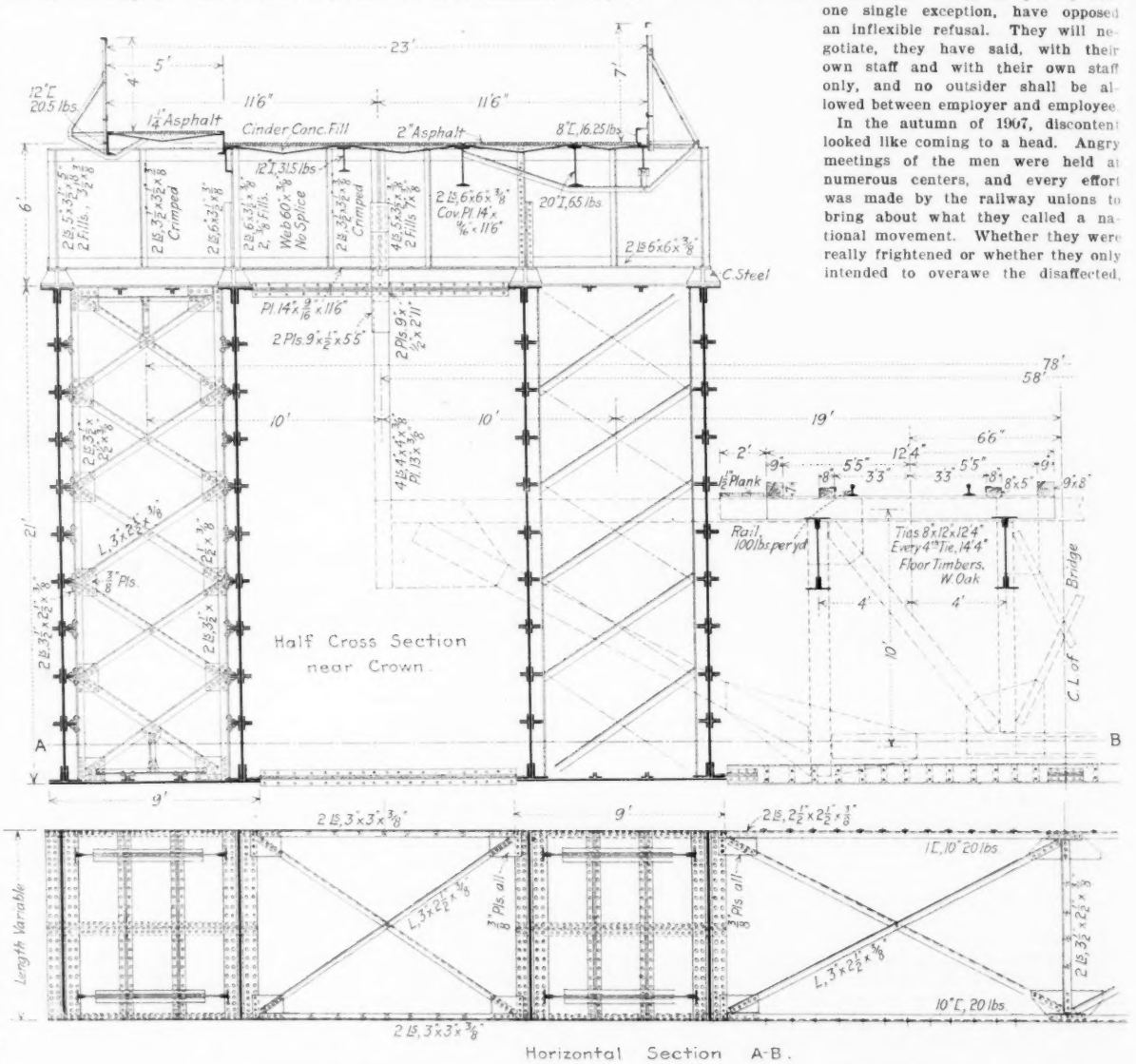


FIG. 2. CROSS-SECTION OF RIB AND ROADWAY, 1,800-FT. STEEL ARCH PROJECT.

half is symmetrical therewith. To bring the dead-load pressure line into coincidence with this curve, extra loading in the form of concrete was added where necessary.

The arch has a hinge at the crown only. This gives a rib without bending (and correspondingly light) at the center, and heaviest at the skewbacks, which, of course, lightens the load to be carried by the erection cables.

Temperature variation was taken as 150° F. Snow loading was not considered, as the assumed live-load corresponds to both tracks and both roadways covered, and this would not occur while the structure was covered with snow.

STRESSES.—A unit-stress of 28,000 lbs. per sq. in. in direct compression was used in designing the ribs. Reducing this unit-stress to 24,000 lbs. per sq. in. would affect only the ribs and the erection plant, and would increase the cost of the bridge by about $500,000. The concrete of piers and braces was proportioned for 400 lbs. per sq. in.

DEFLECTION.—The maximum deflections are: For 75° change in temperature, 3.3 ft. at center. For live-load on middle third of span, 2.16 ft. at center.

COST.—Estimates of the total cost of the structure shown indicate that it compares very favorably with the cost of a cantilever structure, even counting the costly erection plant to be without salvage value. The writer believes that by further study and by working out more economical proportions, it could be considerably cheapened. The design illustrated is not the most economical possible, but is only a complete design used for illustration.

It is believed that the construction shown, when compared with other types of long-span bridge construction, is more rigid, has less deflection, and is practically free from secondary stresses during erection as well as afterwards.

Impending Changes in the British Railway System.*

By W. M. ACWORTH.†

The old edifice of the English railway system is tottering to its fall, and no one yet knows what will take its place. If proof of this assertion be needed, it will be found in the Blue Book before us and in the proceedings that led up to the constitution of the Board of Trade Conference. The old English railway system, which has so often been studied and described by continental observers, was one that relied almost wholly on private enterprise, the force of competition, that reduced State interference to a minimum, and, indeed, in the matter of facilities and public service practically excluded State interference altogether. That system, as I say, is passing away. In the proximate future, we shall have to choose between State regulated monopoly or, as to me seems much more probable, State ownership and State operation. But general public opinion has not at present appreciated either the importance or the imminence of the question. Let us glance very briefly at the recent history.

For some years past there has been a good deal of discontent among the railway servants. Railway employment is not, relatively speaking, as attractive as it used to be. Wages have gone up, hours of labor have gone down; but not, I think, more up or more down than in other employments outside. On the other hand, the work has undoubtedly become heavier. The financial position of English railways is not what it once was, and as dividends have diminished, the demand of the shareholders for economy has naturally increased; and economy has meant heavier pressure on the staff in innumerable ways. Larger and more complicated engines and longer trains mean more work and more responsibility for the driver. More coal burnt per mile means harder work for the fireman; longer trains mean more responsibility for guard and shunters; better loaded wagons, more work and more responsibility for the loaders, and so on. Further, longer and better loaded trains mean fewer trains, and therefore short time for the train staff; or else fewer train men, fewer opportunities for promotion, and fewer vacancies for the trainmen's sons.

The men, or at least large sections of them, have consistently demanded increase of wages, shortening of hours and better conditions of service generally; but all these detailed demands have been summed up and included in one general demand that the railway companies should recognize the railway trade unions and allow the trade union leaders to negotiate on their behalf. To this demand, the railway companies, with one single exception, have opposed an inflexible refusal. They will negotiate, they have said, with their own staff and with their own staff only, and no outsider shall be allowed between employer and employee.

In the autumn of 1907, discontent looked like coming to a head. Angry meetings of the men were held at numerous centers, and every effort was made by the railway unions to bring about what they called a national movement. Whether they were really frightened or whether they only intended to overawe the disaffected, the railway managers took precautions against a strike in a very public manner. Large stocks of coal were accumulated, lists of relief men were drawn up, in some cases men in employment were questioned as to what they would do in case of a strike, such and such a company was reported to have put up emergency lodgings and provisioned them as for a siege, and so on. Needless to say the newspapers "wrote up" the situation, and the public took alarm at the prospect of a general strike. Finally the President of the Board of Trade sent for a certain number of Chairmen and General Managers of the leading railways, and told them that the Government could not allow a general strike to paralyze the business of the country, and that something must be done to relieve the situation. After three or four days' discussion between the President of the Board of Trade and the railway managers behind one set of closed doors, and between the President and the representatives of the railway men behind another set of closed doors in the same building, it was publicly announced that an agreement had been come to. In broad outline that agreement was as follows: The

*From the "Bulletin of the International Railway Congress" for February.

†The Albany, Picadilly W., London.

managers adhered to their refusal to recognize the unions, but they consented that in the last resort the determination as to wages, hours of labor and conditions of employment (except so far as discipline was concerned) should be taken out of their own hands and handed over to the decision of an impartial arbitrator. Sectional conciliation boards, representing different districts and different classes of employment, and central conciliation boards were to be formed by the staff of each railway company, and these boards were to meet and discuss all matters of dispute with their employers. Any matters which could not be settled by discussion and agreement were to be decided by an outside arbitrator, both parties binding themselves to abide by his decision. I may add that since then the boards have got to work, and in several cases arbitrators have been called in and have given their decision. On the whole those decisions have given the men a good deal, though by no means all, that they have asked for, and so far they seem to have been peaceably acquiesced in.

But the discussion between the President of the Board of Trade and the railway companies did not confine itself to the question that brought them together. The railway chairmen, it is understood, expressed themselves strongly to the President as to the difficulty of their position. They were asked, it was pointed out, on the one hand, to make concessions which meant money to the men; on the other hand, to make concessions, also meaning money, to their customers; and at the same time they were called upon by their shareholders to restore the dividends to their former rate. If, they said, they were to give way in respect of their men they were entitled to ask the Board of Trade in return to help them in smoothing over difficulties with the traders and in effecting economies where that could be done without injuring public service. And the President, it is understood, expressed sympathy and promised to do what he could to help.

For, indeed, the railway workmen have not been the only discontented class. The traders have also complained bitterly of recent years that they have had to bear the brunt of the companies' economies. There can be no doubt that in more prosperous days the railway companies spoilt their customers by the lax generosity with which they treated them. Small consignments of goods were sent by express passenger trains, but at ordinary goods rates, to catch outgoing steamers at the last moment. Trucks loaded with only a few cwts. were habitually sent through from one end of the country to the other to meet the convenience of an influential customer, whether merchant or manufacturer. Charges for demurrage were made, but when the trader objected to pay they were not pressed, and so on. More important, perhaps, than all was the abuse of Owners' Risk Rates. A large part of the wholesale business of this country has always been done at Owners' Risk Rates, and these rates, which legally relieve the companies from all liability for loss or damage unless proved to have resulted from "wilful misconduct," often imply a reduction of 20, 30 or 40% below the normal rate. But it had grown pretty much into a habit that a company did not insist on this strict legal right, and paid compensation for loss or damage with a liberal hand. Pressed by the necessity for economy, the companies have in the last few years agreed with one another to insist more strictly on the letter of their bargain with the customer. Trucks are no longer run without a reasonable load, and the influential trader can no longer threaten company A that, if they are not run, he will transfer his traffic to company B, for he now finds the second company just as inflexible as the first. Demurrage charges are not merely made but enforced. Owners' Risk claims are carefully examined, and unless wilful misconduct is proved—and of course in practice the trader hardly ever can prove it—compensation is refused. In some cases, the railway companies have actually gone so far as to open packages, and when they have found goods consigned under a false declaration, they have not merely demanded the difference in rate, but have actually prosecuted the trader for fraud. Human nature being what it is, it need hardly be said that the companies are not as popular with the trading community as they were in the old days.

In December, 1906, nearly a year before the railway servants' agitation reached a head, the President of the Board of Trade received a deputation of traders, and in his reply to them spoke as follows:

> I may say here that in the near future we shall have to reconsider the whole question of railway rates from beginning to end. I have been very much impressed since I came to the Board of Trade with what one speaker has called the great and growing discontent with the whole system, and I am also much impressed with this: I meet some German traders from time to time, and they impress upon me their greatest possible satisfaction with their railway system. Whether the German is a much more contented animal than the Britisher I do not know; but, from what I hear from that country, they are well satisfied with their railway system, and consider that the railway system in that country is doing its very best to assist and to promote industries, and even to develop the weak industries. This is the feeling throughout the whole of Germany, as far as I can see.

Again, in February, 1908, after the workmen's agitation had been got out of the way, he spoke to much the same effect in the House of Commons:

> He had taken the trouble to make inquiries into the working of the State railways in the industrial districts of Germany, and he must say that he had been amazed at the results of that inquiry, which he intended to place in full in a paper before the House. There was general agreement that the State railway administration, in spite of alleged defects, which he could not say were altogether favorable from a labor point of view, was far superior to the old system of private ownership and administration. Several merchants and traders spoke of the advantages they witnessed from, and the value of the co-ordination of railways in Prussia, and said that the uniform administration could not be too highly appreciated, or the services rendered by the Minister for Railways in establishing through rates and special rates for special industries, and in his readiness to meet the wishes of traders and manufacturers. One of his investigators recorded a conversation which he had had with English merchants trading with Germany, who all agreed that from their own experience the Prussian railways, in so far as railway rates were concerned, were directed with more regard to manufacturers' and traders' interests than was the case with regard to private English railways. There were three investigators, who carried out their investigations separately, and they were all agreed that in Germany the trader was perfectly satisfied; that he would no more go back to private ownership than we would go back to private ownership of the post-office in this country. The German system was used as a very powerful machine for the purpose of helping and developing German industry. When that state of things existed in Germany and Belgium, for the House to say they would not inquire into the matter would, he thought, be a mistake. It was forty years since the last inquiry, and he thought the time had come for another inquiry into the whole question.

It was at that time understood that a Royal Commission would be appointed to make the "inquiry into the whole question" that the President thought to be required. No such commission has, however, been appointed, but immediately afterwards, the informal conference, whose report is now before us, was called together at the Board of Trade with the object of "reviewing some of the more important questions that from time to time have been raised between the railway companies on the one hand and the traders and the general public on the other." The conference consisted of about twenty-four persons. Roughly, one-third were representatives of the Government, one-third representatives of the railway companies and one-third were traders.

It will be observed that the object of calling the conference, which is stated to be merely that of reviewing questions arising between the companies and traders and the public, is strictly limited. The paramount question raised by Mr. Lloyd-George in the speeches quoted above, the question whether railway companies should cease to exist in England, as they have ceased to exist in Germany, was not referred to the conference at all. But when we turn to the Blue Book, we find that the bulk of it is occupied with an elaborate report prepared at the instance of the conference on the management of the German State railway systems, and a large part of the remainder is occupied with a series of essays dealing with the question of railway amalgamation, its advantages and disadvantages, and its limitations, legal and practical.

For between the time when the President expressed his sympathy with the railway managers in the autumn of 1907 and the time when the conference sat in the middle of 1908, a new question, more important than the question either of railway servants' wages or railway customers' grievances, had appeared upon the horizon. The companies have, as I have said, been drawing together more closely of recent years in order to present a united front against demands which they consider unreasonable. In 1908 matters went much further. Two great companies, the Great Northern and the Great Central suddenly announced that they had come to an agreement to unite for all purposes except finance—for all practical purposes so far as the outside public are concerned—into a single undertaking. They claimed that, under an old Act of Parliament passed fifty years before, they had a right to do this, provided their agreement was approved by the Court of the Railway Commission. And to that Court accordingly they proceeded to apply. Public opinion, perhaps also the Board of Trade, was a good deal taken aback. Everybody was convinced in the abstract that combination was better than competition, and charming little homilies about the beauties of peace and harmony (inspired, perhaps, by shareholders, who were quite clear as to the advantages of economy) appeared in the newspapers. At the same time the traders, who fancied that the economies might be made at their expense, and who thought that there were still some occasions left when one railway company could be played off against another, gave proofs of practical hostility. And when the case came before the Court, the attorney-general and the solicitor-general appeared on behalf of the Government, not, indeed, as opposing, but still less as supporting; while a whole array of counsel, representing towns and trades and other railway companies, very definitely opposed. In the result the railway commissioners held that the agreement was not such as they had jurisdiction to sanction, and their decision was confirmed some months afterwards by the Court of Appeal. But meanwhile outside the Courts matters had gone much further. A third company, the Great Eastern, had agreed to unite with the Great Northern and Great Central, and they had announced that, if the Railway Commission could not or would not sanction their agreement, they would apply to Parliament. Two other great companies, the London & North Western and the Midland, had also, it was reported, entered into a close alliance, to which, not long after, a third company, the Lancashire & Yorkshire, attached itself. The three companies serving the great coal and iron district of the South of Scotland, the Caledonian, North British and the Glasgow & South Western, at the same time were drawing closer together by means of pools and similar agreements, though no actual partnership was in this case proposed. In South Wales, moreover, the three companies that serve the huge coal trade of the Port of Cardiff had agreed to apply to Parliament for sanction to a scheme for complete amalgamation.

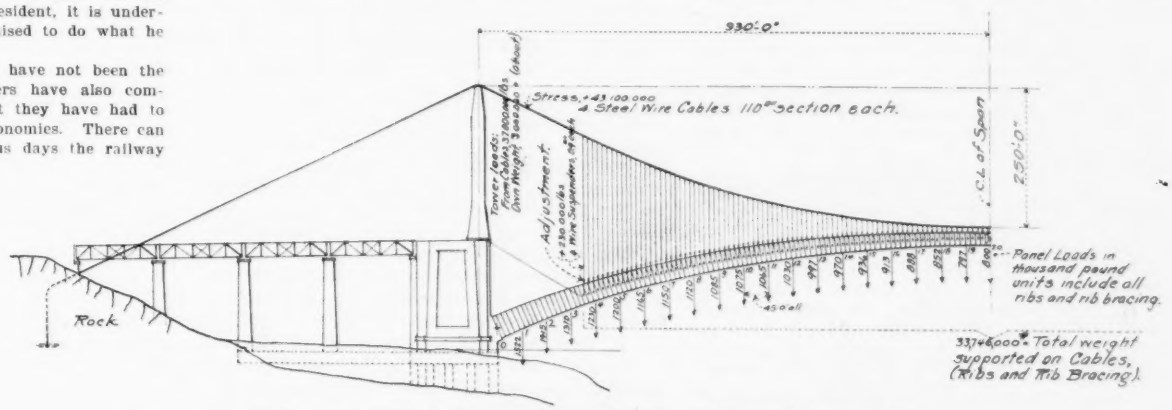

930'-0"
Stress, 41,100,000
4 Steel Wire Cables 110" section each.
C.L. of Span
250'-0"
Tower Loads:
Adjustment.
Rock
Panel Loads in thousand pound units include all ribs and rib bracing.
33,746,000 = Total weight supported on Cables, (Ribs and Rib Bracing).

FIG. 3. SKETCH OF ERECTION, 1,800-FT. STEEL ARCH PROJECT.

What the present position is no man can tell. Agreements abolishing competition throughout almost the whole of Great Britain are still in force as between the companies themselves. That none of these agreements

have obtained the sanction either of the Railway Commission or of Parliament, is clear. How far without such sanction they are legal, and whether, if illegal, they are likely in practice to be upset, is more than anyone can answer. But there in practice they are. Competition in fact is dead, except along the line frontier between what I may call the East Coast and the West Coast Alliance, and not all the King's horses nor all the King's men can bring it to life again.

With the great question of the whole future of English railways looming before them, it is not surprising that the Railway Conference treated in a somewhat perfunctory manner the subjects they were called on to discuss, and filled the pages of their report with discussions on matters they were not primarily instructed to consider. The minor matters on which they have reported are dealt with under twelve heads. The bulk of them can have no interest outside of Great Britain. They deal with such matters as regulations for the carriage of milk and dangerous goods, regulations as to private owners' wagons, and detention of trucks in transit. Of somewhat more general interest is their recommendation for amendments of the procedure before the Railway Commission. The conference suggests that, in order to shorten and cheapen procedure, certain cases might be heard in the first instance by the Registrar of the Court, with or without assessors, but subject in all cases to a right of appeal to the Court itself. Another recommendation, which was based on a full report as to the working of the Railway Councils in Germany, was that "An Advisory Committee on railway matters should be constituted which the Board of Trade should consult on such matters as they might think fit to refer to it." The recommendation is somewhat bald; no reasons are given why the conference came to that conclusion; and no suggestion is made as to how the committee should be constituted.

The bulk of the Blue Book is, as I have said, occupied by (1) a report on the working and methods of management of the German State railways, and (2) a series of essays on the subject of amalgamation. In reference to the German report little need be said except that it is the best (both as being the most complete and as being the most impartial) report on the subject that has yet appeared in England. If any English trader were perchance to read it, which is hardly likely, it might do real good. For one thing, it brings out the radical difference between English and German conditions, and makes clear the absurdity of mere comparisons of gross rates with no regard to the quality of the service given in return. For another thing it makes plain that railway tariffs, even in countries where they are mainly on a mileage basis, are very complicated things, and knocks on the head the common English belief that the lowest rate from one point in the German Empire to another for any class of goods can be ascertained by the office boy out of a sixpenny handbook. Its main purport is, as I read it, that England is England and Germany is Germany, each of the two countries having manners and customs, history and traditions belonging to themselves and to no one else; and that English people have to settle their own railway problem for themselves.

The essays on railway amalgamation are not only a new feature in a Blue Book, lightening with a personal note the somewhat dull monotony of that literature, but are of considerable interest in themselves, for they are mainly written by the general managers of our great railways, and so tend to show the workings of the minds of those who must have the largest influence in molding the railway policy of the future. To those who can read between the lines they also tend to show where each individual man's shoe pinches, and what modification of general principles is in his judgment desirable in the interest of his own particular company. They are, I may add, all the more worth reading owing to the fact that some, at least, of the authors were entirely unaware that they were writing for publication. It is useless for me to attempt to abstract their contents. I will only repeat that they are worth reading at full length.

As one who personally still adheres to the old-fashioned belief in the advantages of competition, I will conclude with a quotation from the first of the essays:

> Every railway man knows that most of the good in our railway system is due to the spirit of emulation and competition. Take away that spur, and British railways would soon cease to be, what with all their faults we have reason to boast they are, the best in the world. When we approach amalgamation, therefore, we do so, not with a desire to eliminate competition where such is desirable, or proper, but solely with a view to the economical development of our railways upon natural lines, and to so strengthen them financially that they may render the fullest possible benefit alike to the districts they serve, the investors who made their construction possible, the manufacturers who supply their wants, and the army of employees who live by them.

The quotation receives additional interest from the fact that the writer is Mr. Sam Fay, General Manager of the Great Central Ry., and General Manager-designate, had the scheme gone through, of the united Great Central, Great Northern and Great Eastern undertaking. We may conclude therefore that, in Mr. Fay's opinion, competition between adequately equipped competitors is desirable, and that the combined Great Central, Great Northern and Great Eastern system is precisely of the economic strength required for adequate competition. We may look forward accordingly to seeing Mr. Fay's great influence and great abilities exerted in this direction. Whether his influence will prevail, is at the moment of writing doubtful.

The Behavior of a Stream Carrying Sand and the Effect of Sand on the Measurement of Bottom Velocity.*

By E. C. MURPHY.†

The changes in the appearance of a stream of water as sand is fed into it in increasing amounts is very interesting and the sand movement which gives rise to these changes has an important bearing on some engineering problems. If the channel bed is even, comparatively smooth and parallel to the water surface, the surface will be comparatively smooth until the stream becomes nearly fully loaded. When overload takes place, the bed will begin to increase its slope and three distinct kinds of sand movement will take place as the slope increases accompanied by striking changes in the appearance of the water surface. In the hydraulic laboratory of the U. S. Geological Survey the writer has observed these changes in a wooden trough about 2 ft. in width with discharge from 0.1 sec. ft. to .75 sec. ft., and with several sizes of debris.

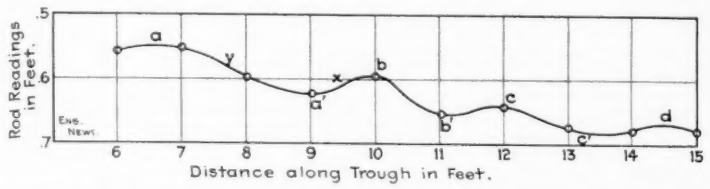


FIG. 1. SAND WAVES FORMED ON BED OF TROUGH CARRYING SAND-LOADED WATER.

The material or load carried by a stream may be in solution, suspension or dragged along the bed. This latter is called bottom or saltation load and the zone in which it moves is called the saltation zone. The total load is the sum of these three kinds of load. In these experiments the bottom load is the total load.

If a stream is fully loaded it will not pick up material of the size it is carrying, if it is overloaded, for when the velocity becomes suddenly reduced, deposit will occur. A stream that is carrying a full load of one or more sizes can carry some load of a smaller size and the addition of the smaller size will increase the capacity of the stream to carry the larger size in the case of stream transportation. We have found that a stream will carry more than four times the weight of the 4-6 size in the presence of a certain weight of the 50-60 size than in its absence.‡

The sand grains begin to move at low velocity and form themselves into irregularly-shaped ridges called dunes at right angles with the direction of the current, instead of moving continuously down the trough. These dunes have a gentle up-stream slope and a much steeper down-stream slope. Their form is continually changing as they move forward, they divide and again unite, the parts traveling at different rates and new ones form on top of the old ones. A grain moves up the gentle slope, falls over the crest, is covered by other grains following it, remains at rest until the dune passes over it, after which it moves over the dune and is again buried. Thus the time a grain is in motion is only a small fraction of the time it is at rest. As the rate of feed increases, the sand slope increasing and increasing the velocity, the size of the dunes and their rate of movement increases. When the discharge was 0.363 sec. ft., load 1.5 lbs. per min. and slope 0.32%, the dunes were 7 to 9 ins. long, 0.5 in. high and moved at the rate of 0.56 ft. per min.; when the discharge was 0.734 sec. ft., load 4.0 lbs. per min., they were 13 to 15 ins. long, 0.75 in. high and moved at the rate of 1.5 ft. per min. As the rate of feed was increased, some of the grains leaped from one dune to the next instead of dropping to the bottom and waiting for the dune to pass over them. The form of the dunes became less distinct and at a little greater velocity they disappeared, leaving the sand surface even and the water surface above it waveless. This condition of waveless surface flow continued while the sand slope increased from about 0.9% to 1.6%, the discharge being .363 sec. ft., and width 1.0 ft. For higher slopes the sand surface formed into waves. These waves were from 2 to 3 ft. in length from crest to crest, extended the width of the trough and some were .05 ft. in height from trough to crest of wave. Fig. 1 shows a profile of a part of the sand surface at the end of an experiment. These sand waves travel slowly up stream, the sand being scoured from the down-stream face in the vicinity of y and deposited on the up-stream face at x. Some of these waves remain for two minutes but generally not longer than one minute. The velocity is greater in the wave trough than in the vicinity of the crest and the motion of the grains at the crest is very complex, some of them jumping almost to the surface. Fig. 2 shows two profiles of the sand surface; in one the sand surface is in waves, in the other it is nearly waveless.

The values of the sand slope between which the surface is waveless depend on the size of the sand and the discharge. The finer the sand and larger the discharge, the smaller the slope at which this condition begins.

The water surface was smooth before the dunes began to form. As the small ones formed, many small waves appeared, and as the dunes increased the waves became larger, fewer in number and canoe-shaped. Two formed side by side when the trough width was 1.0 ft. and three when the width was 1.32 ft. When dune motion ceased they disappeared and the surface was smooth and waveless. This condition of surface continued as the slope increased until the sand bed formed into waves; the water surface then became a succession of waves similar to the sand waves below them. Fig. 3 shows profiles of the water surface, or wave traces. Line A shows the water surface, before dunes begin to form and is similar to the line obtained between the conditions of dune and wave surface motion. Line B shows the surface when small dunes have formed; line C shows the surface for larger dunes and line D shows the surface

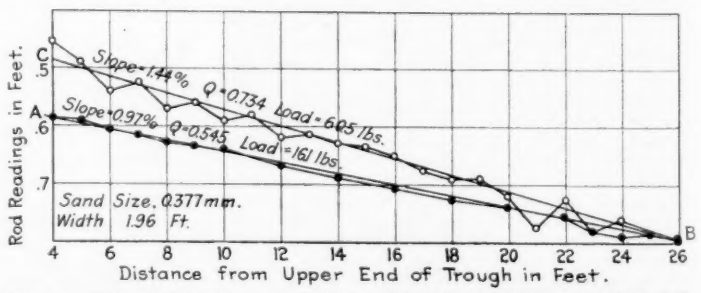


FIG. 2. TWO PROFILES OF SAND SURFACES FORMED UNDER DIFFERENT CONDITIONS; ONE WITH WAVES AND ONE NEARLY WAVELESS.

*Data used with permission of the Director and Chief Hydrographer of the U. S. Geological Survey.

†Engineer, U. S. Geological Survey, 2338 Carlton St., Berkeley, Cal.

[‡These sizes indicate sieves used to separate the sand. The 4-6 size denotes a sieve with openings of 5 to 3.5 mm.; and the 50-60 size indicates a sieve with openings of 0.31 to 0.27 mm. See Mr. Murphy's article on "Effect of Roughness of Bed on Depth of Water and Distribution of Velocity," Eng. News, Dec. 30, 1909.—Ed.]

BOTTOM VELOCITY OF UNLOADED STREAMS.
(Trough width, 1 ft. Slope, 1%. Planed and painted surface.)

Discharge in sec. ft.	Depth in ft.	Mean Veloc. Vm	Surface Veloc. Vs	Bottom (a) Velocity Vb	Bottom (a) Velocity Vb'	Vm/Vs	Vm/Vb	Vm/Vb'
.039	0.034	1.15	1.82	1.44	1.15	0.63	0.81	1.00
.093	0.052	1.79	2.46	2.00	1.80	0.73	0.90	1.00
.182	.078	2.33	3.30	2.40	2.55	0.71	0.97	0.91
.363	.121	3.00	4.23	2.84	3.37	0.71	1.06	0.89
.545	.158	3.45	4.70	3.26	3.85	0.73	1.06	0.90
.734	.194	3.79	5.26	3.45	4.11	0.72	1.09	0.92
.923	.229	4.03	5.57	3.62	4.23	0.72	1.11	0.95

(a). Vb — bottom velocity obtained with beans 5/16 to 6/16-in. long and 3/16 to 4/16-in. diameter.
VB — bottom velocity obtained with glass marble, 0.146 ft. dia.
NOTE.—The marble moves over the smoothest parts of this surface without the aid of the water.

when the sand surface is in waves. These wave traces were obtained as follows: A sheet of galvanized iron, 4 ft. long and 1 ft. high, was ruled into inch squares. This plate was moistened and covered with fine dust. It was held vertical at a given place over the experimentation trough and on signal was dropped into the trough and taken out again as quickly as possible. The dust was removed from the part of the plate in the water leaving a well defined outline of the water surface. This line was quickly drawn on paper by means of the lines forming the squares.

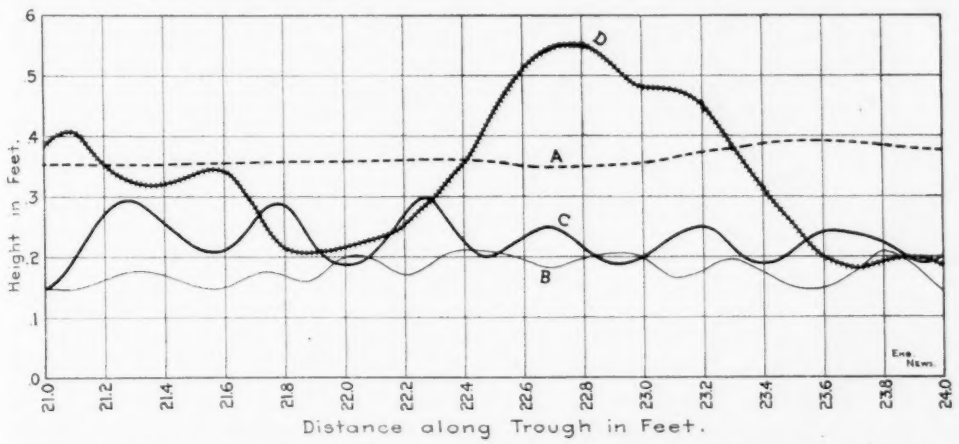


FIG. 3. PROFILES OF WATER SURFACE AS AFF ECTED BY SAND WAVES ON BED OF TROUGH.

Space will not permit a fuller description of these very interesting phenomena of sand transportation, as the writer desires to discuss the effect of the peculiar way in which sand is transportated on the measurement of bottom velocity.

When sand is traveling in dunes the grains move quickly up the slope of a dune, fall over the crest and remain at rest for a time, that is, the bottom velocity on the up-stream face is a foot or more per second and just below the dune is zero.

How is bottom velocity to be measured? If a bean or some object a little heavier than water be used we find it to behave somewhat like a grain of sand, that is, it has an intermittent motion. If a Pitot tube is used the sand scours from under the point when it is brought near the bottom and the velocity shown by it is not bottom velocity but velocity some distance above the bottom.

If the movement of sand and other bodies in water be observed from the side through glass, their motion is seen to depend mainly on the velocity, specific gravity, size, shape and the roughness of bed. If the surface is smooth the flat particles travel mainly by sliding, those nearly spherical by rolling or combined, rolling and jumping. The less the specific gravity and greater the velocity, the higher and longer the jumps. The height of jump is very important in a shallow stream on account of the great relative velocity near the bed. The change in velocity near the bed was often at a rate of 25 ft. per ft. of depth in these experiments.

The bottom velocity over a smooth surface has been measured by the use of beans, pumice, a marble and grains of gravel of various sizes. The following table gives data for beans and a marble. Some of these data are shown graphically in Fig. 4. The bottom velocity obtained with the marble is much greater than that obtained with beans and greater than the mean velocity for these shallow depths. The nearly constant relation between mean and surface velocity is noticeable.

The pumice pebbles move faster than the beans, the beans faster than the sand and gravel grains, and the larger and the more nearly spherical the grains the faster they move. Bottom velocity over a smooth surface is definite when measured by a substance of proper size, shape and specific gravity but in the case of dune motion and wave surface motion, it is variable and indeterminate.

The zone of saltation and that in which the motion of a particle is intermittent is thin. By using sawdust and fibers of water-soaked redwood that travel at different depths below the surface this fact can readily be verified.

It is scarcely necessary to say that it is very difficult to measure depth with a reasonable degree of accuracy when the sand is moving in dunes or in waves. Both the surface and bed at a given point are continually changing shape and elevation and the latter being a mass of moving particles is difficult to distinguish.

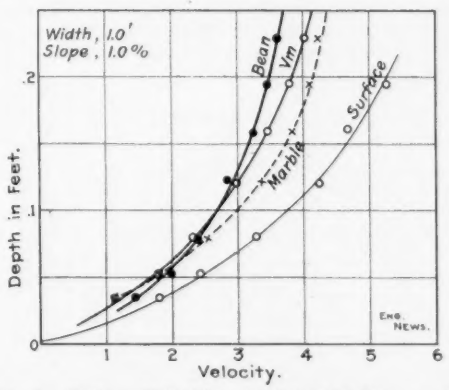


Fig. 4. Bottom Velocities of Unloaded Streams in Trough With Smooth Surface.

MISSISSIPPI RIVER TRAFFIC AT ST. LOUIS in 1909 was only about one-third as great as in 1890. A table in the annual report of the St. Louis Merchants Exchange gives the figures as follows:

	Year. 1890.	1909.
No. of boats arriving	1,927	783
No. of barges arriving	1,274	329
Tons of freight received by water	530,790	251,590
Tons of lumber & logs received by raft	132,940	None.
No. of boats departing	1,910	772
Tons of freight shipped	617,980	48,005

The Scoop-Wheel Pumping Plant at Schellingwoude, Holland.

By CHARLES S. SLICHTER.*

As is generally known, the level of the water in the canals, harbor and polders near Amsterdam, Holland, must be artificially maintained at the desired datum by a complex system of pumping plants and sea locks or sluices. When the rainfall is slight, it is usually possible to waste enough water at low tide to keep the water at Amsterdam at the desired datum. The level of the North Sea Canal is, under ordinary circumstances, held to the desired gage by discharging through the North Sea sluices at Ymuiden, or through the Oranje sluices at Schellingwoude, at which point the inland or minor shipping† from the Amsterdam harbor finds passage through locks into the Zuider Zee. At times, when the North Sea is high and a natural discharge is impossible, the water must be pumped from the canal into the Zuider Zee at Schellingwoude. For this purpose the Amsterdam Canal Co. established some years ago a steam plant on the north side of the Oranje sluices, consisting of three horizontal centrifugal pumps individually driven by three steam engines. This pumping plant never proved satisfactory. The low lifts that were pumped against (from 1 to 7 ft.), and other features inherent in the situation permitted only an extremely disadvantageous and uneconomical operation of the plant. The capacity was also inadequate for the purpose originally intended. All this led the Government, after taking over the whole undertaking from the Amsterdam Canal Co., to instal an entirely new pumping plant on the south side of the Oranje sluices. This new plant consists of two groups of steam-driven scoop-wheels. Its construction and operation has been accompanied by the most significant success. It is the purpose of this paper to describe some of the interesting features of the plant and to give some of the results of its operation.

The new plant is not only designed to handle the water formerly allotted to the centrifugal pumps north of the sluices, but at the same time it was designed to be capable of lifting the water from Amstelland, which emptied into the North Sea canal by the Merwede Canal sluices at Zeeburg. This burden has not only been successfully carried by the new plant, but its construction has led to the practical abandonment of the old centrifugal pumping station, which has not been used for a number of years.

My visit to the Schellingwoude scoop-wheel pumping station took place in August, 1909. The efficient engineer in charge of the operation of this plant, Chief Engineer H. Prins, furnished me with every desired information and gave me every possible facility for the inspection of the plant. To the courtesy of this gentleman is due, in great part, the information and description given herewith.

The special conditions to be met in the design of those works were as follows:

(1) The lowness of the lift; most of the discharge taking place at lifts of from 0.5 to 3 ft.

(2) The enormous capacity required; reaching as high as 1,500 cu. ft. per sec. for lifts under 1.8 ft.

(3) The great variability in the range of lifts; varying from 0.5 to 8 ft.

(4) The intermittent character of the pumping. In a usual year the plant may be operated for only about 45 days in winter, from September to April.

(5) The readiness for emergency operation which the plant must possess. The station is in telephonic communication with the central hydrographic office. It must be ready to respond to a warning of a few hours and an immediate response in a few minutes' notice. On some days the ability to waste water by gravity through the sluices of the North Sea Canal is not certainly known until the very last moment. When the water at Amsterdam shows a certain gage height and water cannot be wasted by the North Sea

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†The sluices at Ymuiden are used by the foreign shipping in large bottoms.

Canal, the pumps must be immediately operated, as the cellars of the city are protected only by an insignificant margin. When the canal water stands 4 ins. above the usual operating datum (1 ft. below zero N.A.P.), the city of Amsterdam must be shut of by her own sluices. When the level of the water is only 1 in. above the usual operating level, the city pumping machinery near Zeeburg must be put in operation. This latter plant discharges the water into the Zuider Zee through tunnels or siphons constructed under the bottom of the Merwede Canal.

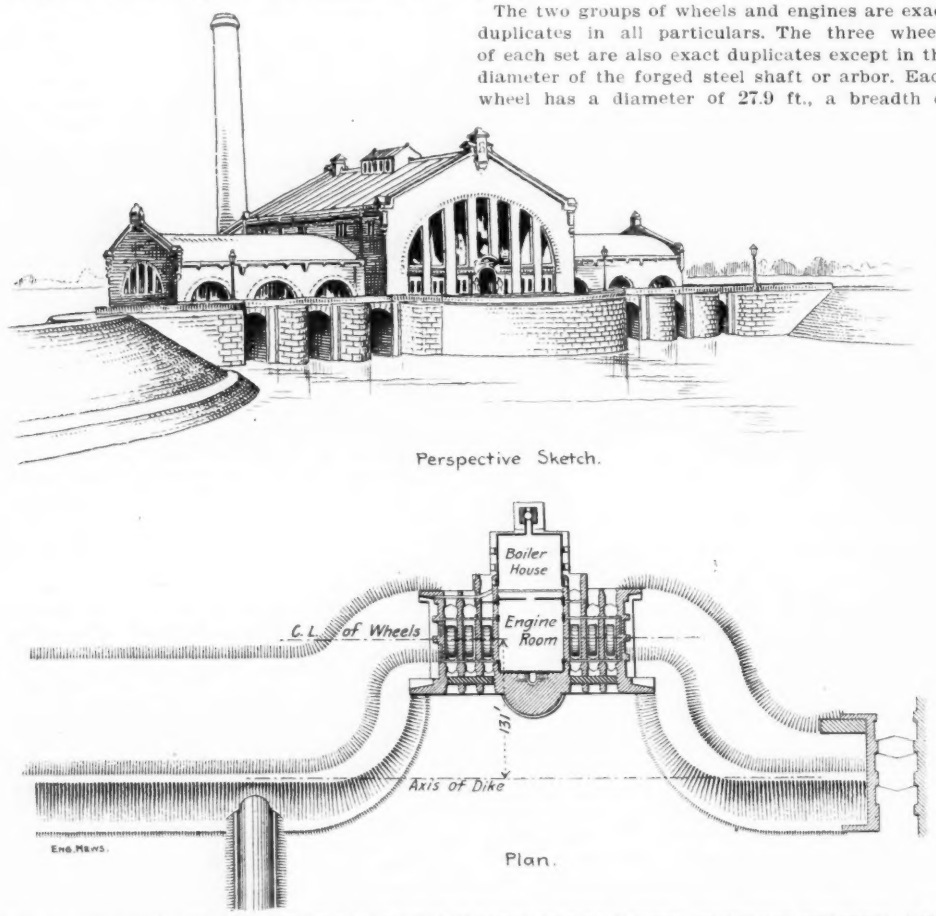


FIG. 1. GENERAL VIEW OF THE SCHELLINGWOUDE SCOOP-WHEEL PUMPING STATION, AND PLAN OF WATER COURSES AND EMBANKMENT.

The new plant was placed in operation in 1901. It consists of six scoop-wheels arranged in groups of three wheels each. Each group is separately driven by its own steam engine. The engines are located in the main building, the wheels are placed in the wing on each side of the main building, while behind the engine room is the boiler room and stack. Fig. 1 is a sketch showing the general plan and arrangement of the works. Fig. 6 is a photograph showing two of the wheels in the north wing.

All elevations quoted in the following and also those inscribed on the diagrams are referred to the new Amsterdam datum, which is designated by the initials N.A.P. The station was designed to develop 300 hydraulic horse power in each unit, based upon an intake lift of 0.98-ft. N.A.P. and a discharge lift of + 0.82 ft. N. A. P. (see Figs. 3-5), but the designers estimated that pumping could take place even with a discharge head of 4 ft. As a matter of fact the capacity has turned out to be much greater than was expected.

Figs. 3-5 give structural details and dimensions of the scoop wheels. The wheels of each group are connected by clutch couplings so that each engine can drive one, two or three wheels as desired. This was done so that at high water two wheels of each group could be uncoupled. As a matter of fact it has never been necessary to uncouple more than one wheel of each set, as the engines have shown themselves abundantly able to perform this duty owing to the unexpected high pumping efficiency of the scoop wheels.

The two groups of wheels and engines are exact duplicates in all particulars. The three wheels of each set are also exact duplicates except in the diameter of the forged steel shaft or arbor. Each wheel has a diameter of 27.9 ft., a breadth of 9.8 ft. and a "bite" of 5.1 ft. There are three cast-iron wheel frames on the forged steel axle of each wheel. There are 24 straight paddles connected with one another by iron rings bolted to the wheel frame. The paddle blades are tangent to a circle, called the "discharge circle," with a radius of 3.85 ft., which was so selected that the angle between the entering paddle and the level of the intake water is equal to half the angle formed by the emerging paddle and the surface of the discharge water—the former calculated at—0.98-ft. N.A.P. and the latter at + 0.82-ft. N.A.P.

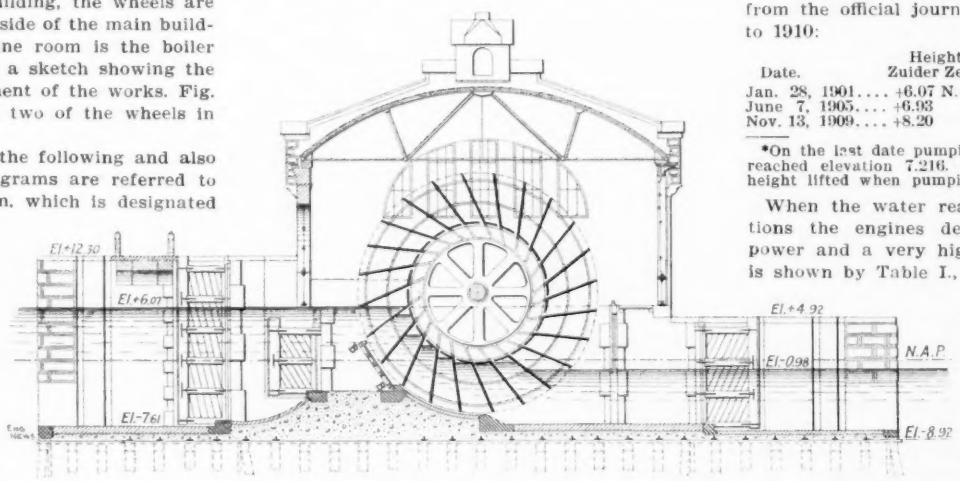


FIG. 2. LONGITUDINAL SECTION THROUGH SCHELLINGWOUDE SCOOP-WHEEL, SHOWING POSITION OF MOVABLE BREAST AT B B.

Between the paddles and on a circle that is tangent to elevation zero N.A.P. there is bolted a continuous plank partition which keeps the water out of the central portion of the wheel at high water. This device adds materially to the efficiency of the pump, especially at high tide. Thin strips of galvanized-iron flashings are fastened to the edge of the wooden paddles to lessen the play between the wheels and the concrete walls. The clearance between the flashing and concrete is reduced to about ¼ or ⅜-in.

One of the most important features of the hydraulic unit is the movable breast. One of these is placed on the discharge side of each wheel and hinged at its lower edge so as to swing about a horizontal axis. The breast is shown in position at B B, Fig. 2. The movable breast is free to take a natural and unrestrained position in the current of the discharging water, except that iron supports are placed in front of the wheel to prevent the breast being thrust against it. The breast is constructed of heavy planking and angle iron. It should be emphasized that it is the movable breast more than any other feature that gives to this scoop-wheel plant its remarkable showing of high efficiency under extreme variability in the head. The breast automatically takes up a position during operation that leads to high efficiency.

For the control of the water in the intake and discharge sides, each water course is provided with a pair of storm gates, a pair of flood gates, and a pair of ebb gates. A sliding gate behind the scoop-wheels has never been used, since there has been no need for it. The sliding gates were only intended to protect the wheels and gearing from damage by waves in the canal during stormy weather.

The scoop-wheel was originally designed to withstand no greater sea pressure than + 4.4 ft. N.A.P. With this in view the walls were built to a height of only + 6.5 ft. N.A.P. A water level of + 4.0 seldom occurs, yet occasionally it has been greatly exceeded, as a maximum of + 8.5 ft. N.A.P. on Dec. 7, 1895, abundantly shows. It has therefore become necessary to handle a greater height than + 4.0. This has been accomplished by the erection of a small wall on top of the side walls of the inner pair of wheels (the third wheel of each group cannot be used when discharge water is at elevation + 4.0 N.A.P.), the elevation of the supplementary wall being + 9.5 ft. N.A.P. When the water in Zuider Zee reaches elevation 7.2 ft. pumping must cease.

That the wheels can be operated advantageously in times of high water has been abundantly demonstrated both by artificially increasing the water level in the discharge courses by means of planks during tests and by actually operating four wheels on several dates of high water in the Zuider Zee.

The following records of high lifts are taken from the official journal covering the years 1900 to 1910:

Date.	Height of Zuider Zee, ft.	Height of canal, ft.	Height lifted, ft.
Jan. 28, 1901....	+6.07 N.A.P.	—0.653 N.A.P.	6.725
June 7, 1905....	+6.93	—0.787	7.717
Nov. 13, 1909....	+8.20	—0.886	8.102*

*On the last date pumping ceased when the Zuider Zee reached elevation 7.216. The number tabulated is the height lifted when pumping ceased.

When the water reaches these unusual elevations the engines develop a large amount of power and a very high efficiency is reached, as is shown by Table I., which gives the results of a test by H. van Oort (De Ingenieur, No. 36, Sept. 7, 1901, pp. 591-594).

Table II. gives the results of pumping and the capacity and efficiency at the usual stages of water. These tests were made in December, 1909, and permit comparison with the tests made eight years previous, reported in Table I., as the lifts slightly overlap in the two instances.

The discharge given in both Tables I. and II. is calculated from the following formula, due to Prof. D. Grothe of the Polytechnic at Delft:

$$V = n\ [2\pi\ (r - \tfrac{1}{2}d') - m\delta]\ d'c$$

in which V is the total discharge in cu. m. per min.
n is the no. of revol. of scoop-wheel in meters.
r is the radius of scoop-wheel in meters.
d' is the radius in meters of submerged portion of paddle.
π is the 3.1416.
m is the number of paddles.
δ is the thickness of the paddle blades in meters
c is the length of the paddle blades in meters.

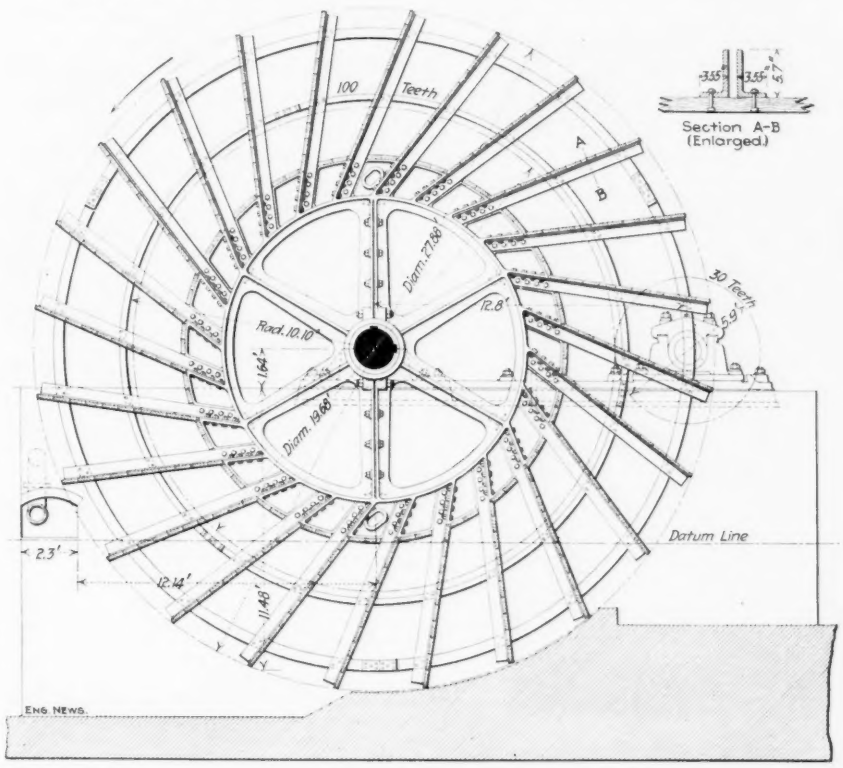


FIG. 3. LONGITUDINAL SECTION PERPENDICULAR TO AXES OF SCHELLINGWOUDE SCOOP-WHEEL SHOWING ANGLE OF PADDLES AND DISCHARGE CIRCLE.

From the results given by this formula, 10% slip has been deducted to allow for return water between the paddles and the concrete walls. In the judgment of the writer this allowance is more than sufficient, even at high water.

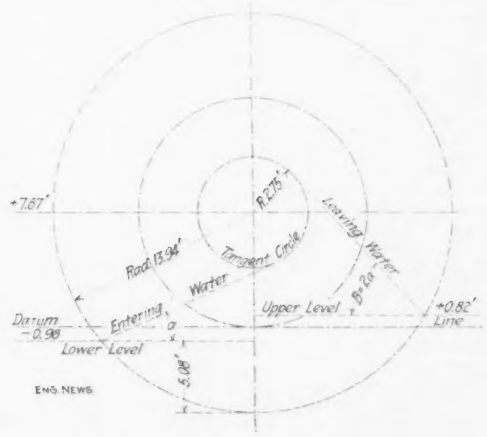
The higher efficiencies in the tables appear more remarkable when it is remembered that they are computed from indicated horsepower to hydraulic horsepower. The actual power transmitted to the scoop-wheel shaft must be estimated to be less than 85% of the indicated horsepower, so that the actual efficiency of the hydraulic unit is remarkably high. In the lower lifts a large per cent of the energy must inevitably go into the velocity head of the discharging current. An interesting estimate of the distribution of useful work, energy in velocity head and miscellaneous losses is given in Table III. The amount of "useful work" (or net hydraulic efficiency) given in Column 2 of the table is formed by estimating the power delivered to the shaft of the scoop-wheel as 85% of the indicated horsepower. The first ten lines of the table are based upon data taken from Table II., and the last three lines upon data from Table I. From Table III. it will be noted that the efficiency of the scoop-wheel considered as a pump reaches as high as 89% and that the loss due to velocity head for the higher lifts is as low as 6 or 7%.

I have carefully observed the discharge and intake water during the operation of this plant. The currents of the entering and discharging streams of water were most remarkable on account of the freedom from eddies and cross currents and other signs of wasted energy. The freedom from noise in the machinery and of undue commotion in the water currents gave satisfactory corroboration of the high efficiency of the plant as shown by the data tabulated in the tests.

From the tables given above it will be seen that the output will average from 500 to 550 hydraulic horsepower for the two units. The coal consumption can be estimated to be about a ton an hour, or to average, under all lifts, about 4 lbs. per water horsepower. Table II. gives the coal consumption during the tests in December, 1909. During the tests tabulated in Table I. the coal consumption averaged 3.40 lbs. per water horsepower-hour.

The actual capacity of the plant for various lifts and also the efficiency at these lifts are shown graphically in Fig. 7, a diagram constructed from the data in Table I. and II. The capacity shown is for one engine unit, or one-half the whole plant.

The engines are horizontal compound, possessing no specially noteworthy feature except the valve and expansion gearing, which is of unusual merit. It is known as the Hertaz gear and is manufactured by the Phoenix Co. of Ghent, Belgium. The surface condensers and air pumps are placed under the floor of the engine room. The high-pressure cylinder has a diameter of 2.034 ft., the low-pressure cylinder has a diameter of 3.281 ft., and the length of the stroke is 3.281 ft. The speed of the engine varies between 40 and 50 r. p. m. The engines are geared to the wheel shaft in the ratio 10



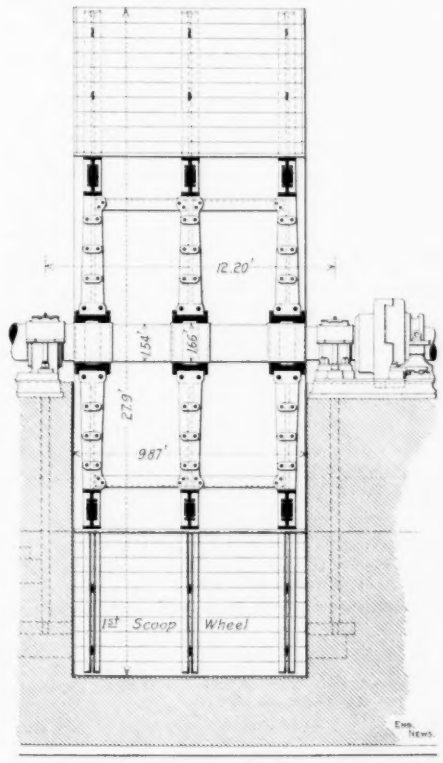


Fig. 4. Vertical Section Through the Axes of North Group of Scoop-Wheels at Schellingwoude.

TABLE I.—TEST OF THE SCHELLINGWOUDE SCOOP-WHEEL PLANT DURING HIGH WATER.

(The data are for the north unit only. The south unit is a duplicate in every particular.)

Times, A. M.	Elev., intake water, ft., —N.A.P.	Elev., discharge water, ft., +N.A.P.	Total lift, ft.	Revolutions of scoop-wheel, per min.	Total water pumped, cu. ft. per sec.	Horsepower metric: Indicated.	Hydraulic	Efficiency H. HP. / I. HP. per cent.	Remarks.
7	0.62	5.94	6.56	3.8	432	437	325	0.74	Only two wheels in use
7.30	0.59	5.75	6.34	3.9	443	455	324	0.71	
8	0.59	5.50	6.09	3.8	434	464	304	0.65	
8.30	0.59	5.58	6.17	3.9	445	473	316	0.67	
9	0.59	5.60	6.19	4.0	457	444	326	0.76	
9.30	0.59	5.10	5.69	4.0	457	414	300	0.74	
10	0.59	4.60	5.19	4.1	468	425	268	0.63	
10.30	0.59	4.43	5.02	4.1	468	410	270	0.66	
11	0.52	4.25	4.77	4.2	481	400	265	0.66	
11.30	0.52	4.30	4.82	4.15	476	407	266	0.65	

TABLE II.—TEST OF THE SCHELLINGWOUDE SCOOP-WHEEL PLANT DURING MODERATE STAGE OF WATER.

(The data are for one pumping unit only. Three wheels were operated while the data in first seven lines were taken, two wheels while the last three were taken.)

Total lift, ft.	Revolutions of scoop wheel per min.	Total water pumped, cu. ft. per sec.	Horsepower, metric: Indicated.	Hydraulic	Efficiency H. HP. / I. HP	Coal consumed per hydraulic HP.-hr.	Steam admission, H. P. cylinder, per cent. cut-off.	Remarks.
1.57	4.4	752	329	136	0.41	6.4	25	Steam pressure
1.81	4.5	760	347	158	0.45	5.5	25	6 atmospheres;
2.13	4.4	755	351	185	0.52	4.9	37	average vacuum,
2.80	4.3	685	359	231	0.64	4.9	37	27½ ins.
3.42	4.1	655	374	257	0.68	5.5	50	
3.72	3.9	643	399	274	0.68	5.5	50	
4.10	3.9	655	451	309	0.68	4.3	50	
4.57	4.3	527	456	276	0.60	3.5	55	Two scoop-wheels
5.00	4.3	525	458	305	0.66	3.7	55	in use for last three
5.45	3.8	413	438	288	0.65	4.3	55	lines of table.

TABLE III.—ESTIMATE OF THE DISTRIBUTION OF USEFUL WORK AND LOSSES FOR VARIOUS LIFTS, SCHELLINGWOUDE SCOOP-WHEEL.

Total energy delivered to wheel shaft = 100					
Total lift, ft.	Energy as useful work, %.	Energy as velocity head, %.	Energy in misc. losses, %.	Remarks.	
1.57	48	25	27	Three	wheels.
1.81	53	22	25	"	"
2.13	61	19	20	"	"
2.89	75	14	11	"	"
3.42	80	12	8	"	"
3.72	80	11	9	"	"
4.10	80	9.8	10.2	Two	wheels.
4.57	71	8.8	20	"	"
5.00	78	8	16	"	"
5.45	76	7.3	17	"	"
4.82	76	8.3	15.7	"	"
6.19	89	7	4	"	"
6.56	87	6	7	"	"

to 1. The working steam pressure is 6 atmospheres or 85 lbs. per sq. in. Circulating water is supplied by two double-acting Worthington pumps having a capacity of 750 gals per in. each.

matter, however, it must be remembered that the plant is operated only intermittently and that first cost as well as life under operating condition plays an important part in the selection of steam generators for such a plant. Eight men are employed at the plant and are retained for substantially the entire year.

The steam consumption under usual operating conditions is given in Table IV. On three of these dates the steam consumption is separately given for the hours when three and when two wheels of each set were operated. The coal consumption for these dates is, however, only known for the entire operating period, so that it is necessary to average the used coal over both periods.

Out of the numerous data at hand it is possible to construct a table showing the operating conditions for various lifts, as in Table V. The duty is there expressed in pounds of steam per hydraulic horsepower-hour.

At low lifts the engines are operating under cut-off in high pressure cylinder as low as 20% and at high lifts at 65%, the steam consumption per indicated horsepower varying as shown in the fifth column of the table. Owing to the extraordinary high efficiency of the wheels at high lifts, it is seen that the steam consumption per hydraulic horsepower varies but little. The numbers given in the last column of table vary but slightly from a mean value of 34 lbs. steam per hydraulic horsepower-hour.

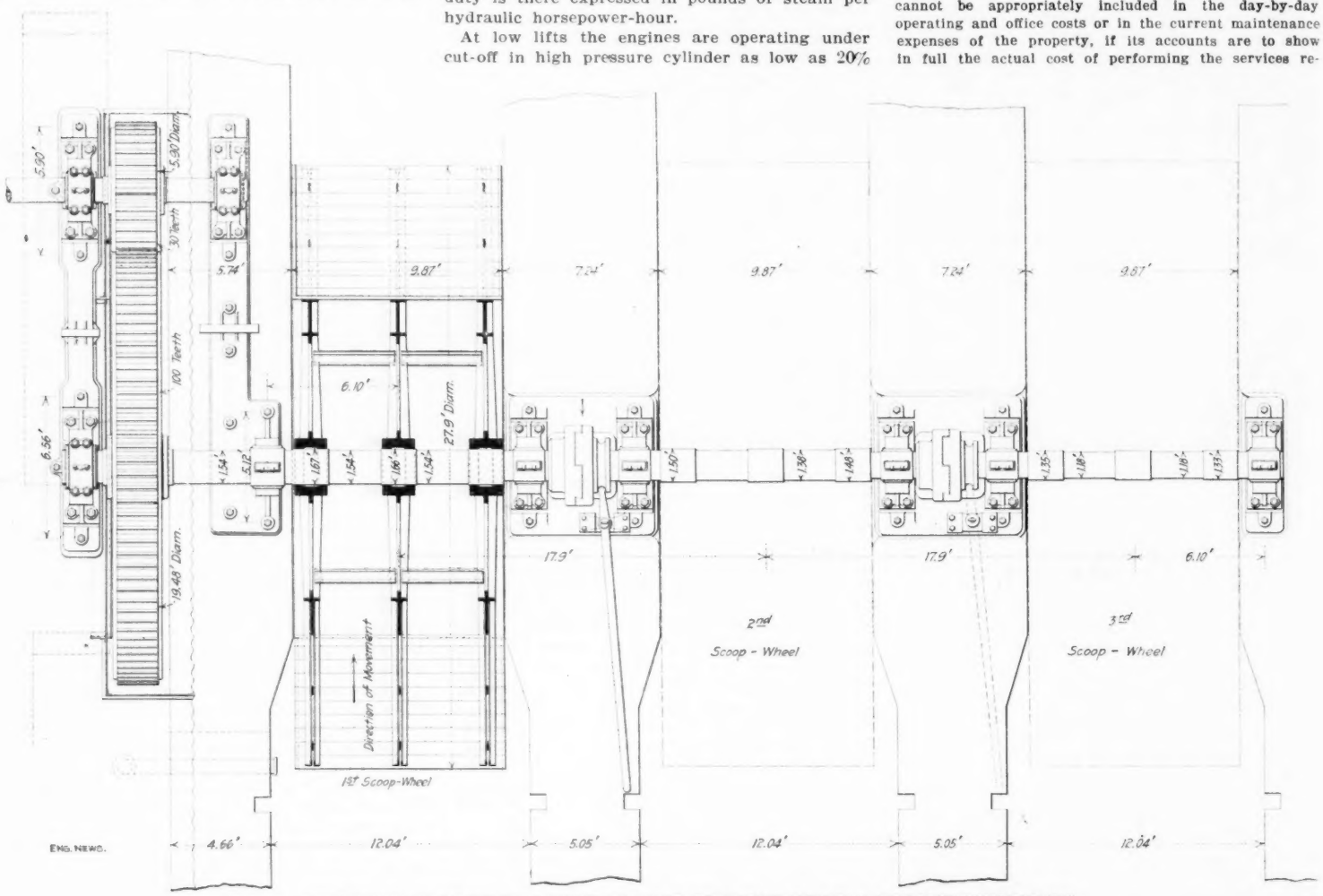


FIG. 5. SECTIONAL PLAN OF THE NORTH GROUP OF SCOOP-WHEELS AT SCHELLINGWOUDE.

The steam is furnished by six Lancashire boilers with Galloway tubes. Dimensions of boilers are: diameter, 7.22 ft.; length, 32.8 ft.; diameter of fire tubes (two), 2.85 ft.; heating surface of each boiler, 1,100 sq. ft. The economies of the plant cannot be attributed to any special excellencies in the steam-producing end. In fact, it is soon intended to replace the battery with boilers of another type. In considering this

TABLE IV.—STEAM CONSUMPTION AT SCHELLINGWOUDE SCOOP-WHEEL STATION UNDER OPERATING CONDITIONS.

(The approximate total lift may be found by adding 0.80-ft. to height of Zuider Zee.)

Date.	No. of engines.	No. of scoop-wheels.	Hrs. & min. operated.	Average level of Zuider Zee above N.A.P., ft.	Steam used per hr., lbs. By two engines.	Steam used per hr., lbs. By two circulating pumps.	Steam used per hr., lbs. Total per hr.	Coal used per hr., lbs.	Cut-off. H. P. cylinder, %.	Lbs. steam per lb. coal.
Jan. 28, 1901.....	2	3	7:15	3.12	15,870	2,380	18,250		50	
	2	2	15:45	4.49	17,620	2,380	20,000	2,580	65	7.4
Jan. 7, 1905.....	2	3	7:40	3.71	20,020	2,380	22,400		65	
	2	2	14:15	5.64	18,270	2,380	20,650	3,000	65	7.1
Jan. 30, 1907.....	2	3	24:00	2.56	11,750	2,150	13,900	2,570	35	5.4
Sept. 3, 1909.....	2	3	24:00	2.03	9,650	2,150	11,800	2,480	28	4.8
Nov. 13, 1909.....	2	3	11:30	1.35	11,850	2,150	14,000		21	
	2	2	11:30	5.08	20,220	2,380	22,600	2,350	65	7.8
Dec. 7, 1909.....	2	3	24:00	0.20	7,090	1,910	9,000	1,650	20	5.5
Dec. 24, 1909.....	2	3	24:00	0.92	8,790	1,910	10,700	1,650	20	6.5
Dec. 26, 1909.....	2	3	24:00	0.23	6,910	1,910	8,820	1,650	20	5.0

The cost of the works is given by Chief Engineer Prins as follows:

Excavations	$30,800
Foundations	44,000
Buildings	85,600
Machinery and boilers	66,600
Coal handling and storage	2,890
Traveling crane, superintendence, rebuilding of dwelling houses, etc.	13,900
Total	$243,790

Depreciation, Salvage and Insurance in Industrial Plants with Especial Reference to Electric Utility Properties.*

By WM. B. JACKSON,† M. Am. Soc. M. E., M. Am. Inst. E. E.

Every company operating an electric light and power property, a street-railway property, or a telephone property, or contemplating entering into any such field of activity, must take into account certain expenses that cannot be appropriately included in the day-by-day operating and office costs or in the current maintenance expenses of the property, if its accounts are to show in full the actual cost of performing the services required. This refers to the sums of money that must be set aside to cover depreciation replacements and to provide a reserve or insurance fund to care for extraordinary costs as hereafter explained.

The term "depreciation" as here used may be divided into two parts:

(1) Decrepitude.—Which covers the gradual wearing out of the apparatus from the effects of use and of age.

*From a paper read before the Western Society of Engineers at Chicago, April 27.

†D. C. & W. B. Jackson, Consulting Engineers, 508 Commercial National Bank Bldg., Chicago.

TABLE V.—DUTY OF SCHELLINGWOUDE SCOOP-WHEEL UNDER ACTUAL OPERATING CONDITION FOR VARIOUS LIFTS.

(The results are averaged from the data in Tables I.-IV.)

Total lift, ft.	Total steam used hr., lbs.	I. HP.	H. HP.	Lbs. steam per I. HP. hr., lbs.	Lbs. steam per H. HP. hr., lbs.	Remarks.	
1.5	10,000	650	270	15.5	37	Three	wheels.
2.0	10,900	700	350	15.6	32	"	"
3.0	13,600	740	480	18.4	28.4	"	"
4.0	19,000	820	600	23.0	31.7	"	"
5.0	20,900	845	545	23.8	38.2	Two	wheels.
6.0	21,200	900	620	23.6	34.2	"	"
6.5	22,000	915	650	24.0	34.0	"	"

which cannot be overcome by current repairs, and which results eventually in ending the operative life of the apparatus.

(2.) Obsolescence.—Which takes into account the reduction in the useful life of apparatus, on account of advances in the art whereby otherwise operative apparatus is made uneconomical for further use.

The term "reserve fund," as here used, may also be divided into two parts:

(1.) Required Reconstruction.—Which takes into account reconstruction costs made necessary by municipal or other legislative requirements.

(2.) Special Insurance.—To cover expenses that cannot be forecast with any degree of certainty, caused by extraordinary occurrences such as unusual storms, explosions, great conflagrations, acts of strikers, etc.

DIVISION OF A PLANT FOR STUDY.—In considering "depreciation" it is well to clearly separate in one's mind the annual depreciation of the plant as an average whole and that of the component parts making up the plant. To obtain the true amount of the annual depreciation in the value of any property, it is necessary to estimate a sum of money which represents the yearly depreciation of each of the component parts of the plant, and the aggregate of these sums of money for all parts of the installation gives the annual depreciation for the plant. This may be converted into a percentage on the total value of the installation which is subject to depreciation. Any method of arriving at the amount of annual depreciation that does not take into account the individual depreciations of the component parts of a plant, must be an approximation at best, even though it may be based upon results obtained in a correct manner for other similar plants, and it may be very far from accurate.

This division of a plant into its component parts for purposes of determining its annual depreciation is usually a simple matter. It requires that each of the component parts shall be such that when it has reached the end of its useful life the part in its entirety will be discarded, and that it shall be possible to intelligently determine its probable salvage value as a whole. If these requirements are not fulfilled the part should be divided until they are. Thus, if we consider the overhead distribution lines of an alternating-current electric-light plant, the lines may be divided into the following parts: bare wire, weatherproof wire, rubber-covered wire, transformers, lightning arresters, insulators, and poles and cross-arms with their hardware. In some cases there may be further divisions. The poles and cross arms with their hardware can usually be considered together as one part, as cross-arms and hardware generally outlast the poles, but seldom are used again when their corresponding poles are discarded. It will be seen how impossible it would be to determine a fair amount for the depreciation of poles and wires without thus analyzing the aggregate, owing to the widely different useful lives of the two kinds of plants and the great difference in the proportions of their salvage values.

Consider electric-railway track. There are the ties with short life and no salvage; there are the rails with medium life and good salvage; there are the frogs and switches with short life and low salvage; and there is the electrical bonding which may be considered as having the same life as the rails and to have medium salvage. It would be impossible to determine a fair annual depreciation for track considering all of these parts together, but it is possible to obtain the fair average depreciation by taking the aggregate of the amounts found by considering the several parts individually.

SALVAGE.—The total amount of depreciation to be annually charged against any part of the installation should be equal to the first cost of the part installed ready for service plus the cost of removal, less any salvage obtainable for the part when discarded, divided by the years of probable life of the part.

The estimation of what is the fair useful life for any part of a plant presupposes a thorough knowledge of the nature of the service demanded of the part, a broad acquaintance with the general experience respecting like kinds of plant, a studied survey of the probable effect of local conditions upon the useful life, and a keen knowledge of the past and present progress of the art for the purpose of making an intelligent forecast of the rate of depreciation caused by approaching obsolescence. A fair determination of the useful life is thus based upon several independent variables, and the result must be reached by judgment after duly applying what seems to be due weight to each of the factors involved.

In estimating the fair salvage value to be assigned to any part of an installation, it is often possible to fix it by some relation to the actual junk value of the materials comprising the part. For instance, the salvage value of a lead-covered paper insulated cable that has finished its useful life will be substantially the residue of the junk value of the lead melted off, and of the copper with the paper burned off after the cost of withdrawing the cable from its place of service and preparing the junk has been deducted (though sometimes cable rejected for use in one kind of service may be used in another, in which case its value when discarded from its original use may be the value of cable that would ordinarily be used in the second service, assuming good engineering judgment in the construction and operation of the property).

The matter is not simple with buildings and machinery. With the former it will frequently be found that the cost of removal will equal the junk value; while with the latter the price that can probably be obtained from a second-hand dealer for the machinery, in place, may sometimes be considered as the salvage value, and in

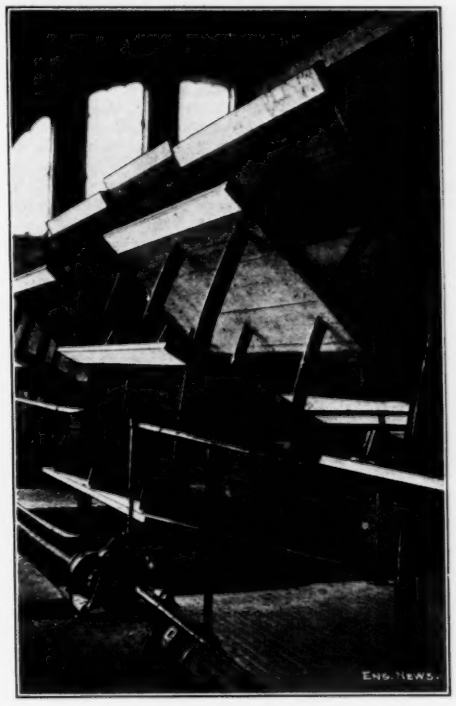


Fig. 6. View Showing Two Wheels of North Group at Schellingwoude.

other cases the salvage value may be regarded as the price that can be obtained from an old metal or junk dealer for the machinery in place.

OBSOLESCENCE.—The factor of obsolescence entering into the question of useful life of plant is a disturbing one. This has the effect of reducing the estimated useful life of many parts of most plants below that which would be indicated by the ravages of decrepitude, and it likewise affects the probable salvage. Where the factor of obsolescence is estimated as likely to terminate the useful life of a part before decrepitude would be likely to cause its rejection, the former factor must determine the useful life. Consequently, the factor of obsolescence may be the determining factor in fixing the length of the useful life of some parts of a plant, and decrepitude may be the determining factor in fixing the length of useful life of other parts. In other cases these two factors may jointly influence the length of life. The factor of obsolescence has been an exceedingly im-

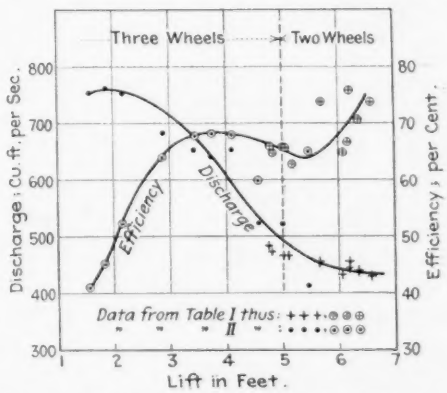


Fig. 7. Variation of Discharge and Efficiency for Various Lifts, North Group, Schellingwoude Scoop-Wheels.

portant one in electrical properties and especially so in connection with all kinds of switchboards and other controlling apparatus. But its effect is very apparent, even when considering what we think of as the most stable parts of an electric generating plant, though revolutionary effects are not so apparent to-day as they have been in the past. Let us consider a large high-grade engine-generator set for alternating currents. Few would be willing to place at less than 50 years the period during which such a machine should be physically capable, under good care and management, of doing the particular work for which it was designed. But no conservative engineer, when estimating depreciation, would allow that such a machine will have a useful life of 50 years, because advances of the art would inevitably affect its usefulness. In consideration of the great changes that have taken place in the past in apparatus for the generation and distribution of electric power, and the probable changes that will take place in the future, such a piece of apparatus cannot appropriately be allowed an estimated useful life of over 20 to 30 years. Local conditions also may influence to a considerable degree the length of the useful life that may be allowed.

RESERVE FUNDS, INSURANCE, ETC.—Most public-service companies are forced to make large expenditures by ordinances of municipalities or by other legislative action. These are required changes, such as changes from overhead construction to underground construction, relocation of distribution lines on account of new street surveys, changes from wooden poles to iron or steel, changes in track construction owing to paving of streets, etc. The costs of such changes up to the value of the original construction should not be made an addition on capital investment and they cannot appropriately be considered as a part of current maintenance, but they should be provided for by a "required reconstruction fund." An adequate estimate of a suitable yearly contribution, on account of required reconstruction, can only be accomplished after a careful study of what expenditures have been made in the past on account of required changes in the plant under consideration, accompanied by a study of the district served by the plant with the view of forming a judgment of what requirements are likely to be imposed in the future. In the case of changes from overhead to underground line construction that are likely to be required, it is sometimes possible to make quite definite estimates of the cost of such changes for many years to come by a study of the character and probable rate of development of the territory covered by the company's lines from which an estimate can be made as to what will normally become underground territory year by year. In some cases a regular schedule of such changes is determined by city ordinances.

The question of what annual charge should be made on account of "special insurance" is also difficult to solve with exactness, but it is one of which sight should not be lost. The ordinary maintenance expenses should not be expected to include such costs as those occasioned by the destruction of a power-house roof by a wind storm, by the annihilation of a boiler-room by a boiler explosion, or by the razing of a pole line by sleet and storm. It is, therefore, appropriate that an annual amount be laid aside for each part of the plant, except, of course, land, to create a fund to remedy such damages which come once in a while to every plant. The element of chance must enter very largely here, but chance is not such a fickle factor in operations when its effects are distributed among many parts of a plant.

These factors of "required reconstruction" and of "special insurance" are quite different in their characteristics from depreciation, but a plant will just as surely get into the breakers, if its reserve fund, or some equivalent to meet these expenses, is not kept in good shape as when no provision is made to take care of depreciation.

If replacements are taken care of by capital account, a property becomes burdened by an imaginary capital investment in physical property which is almost sure to be a serious handicap when the company desires to reduce rates or make improvements. Where replacements are permitted to be taken care of by capital account, the capital account becomes something like the wall-paper in a room (to use a homely comparison) which has been put on, layer upon layer, the old not having been removed when the room is newly papered. The papering is not worth more than the last effective layer, and in fact the lower layers sometimes prove the destruction of the whole, and so it may be with an inflated capital account.

By capitalizing replacement costs, the burden of carrying these costs is thrown upon the future without limit of time in cases of unlimited franchises, when this burden should have been borne by the past, except during the period in which a company is still in process of building up its business to a remunerative one.

A third division is sometimes made in depreciation, called "inadequacy." This factor covers costs which are occasioned by the necessity of discarding otherwise serviceable plants on account of growth of business. For example, if an electric plant is operating with three small dynamos, and it is found necessary to increase its capacity, it may be best to displace one small dynamo by a larger one, even though the small dynamo may be far short of having operated during its entire useful life, estimated from the standpoint of depreciation. The fund accumulated on account of depreciation for this dynamo, plus the salvage, would likely not cover the loss occasioned by discarding the apparatus at that time. This difference might be made up by a contribution to the depreciation fund on account of inadequacy. This factor should be of small importance in a plant planned

and operated with excellent engineering judgment, and it is so closely allied to obsolescence that it does not seem necessary to add a third division to depreciation. It may be properly considered as a part of obsolescence wherever it enters as an appreciable factor in any consideration of depreciation.

The expenses that are considered in the foregoing pages are as real as the pay-roll and other daily operating expenses of a plant, but the ravages of depreciation frequently do not show to a noticeable degree until several years after the beginning of the operation of a plant, and there are also likely to be long periods during which it is unnecessary to make much, if any, outlay on account of required reconstruction and special insurance. For these reasons there is serious danger of overlooking the importance of these expenses in promoting a new enterprise, or in the early days of the operation of a public service company. But if the earnings of a company, after it has become well settled in its business, are not sufficient to cover a fair appropriation annually to the depreciation and reserve funds, as well as to cover the regular operating expenses and a reasonable return on the investment, that company is one that conservative investors should shun. If the conservatively estimated earnings of a new project do not show that they will provide such returns, it should not be considered an attractive project.

APPLICATION OF PRINCIPLES. — Most plant managers have not yet come to a full appreciation of the dire straits a plant must come to sooner or later if the depreciation appropriations or their equivalent are not systematically and intelligently attended to. We may consider, for example, a property having a large investment in pole lines. This may amount to as much as 10% of the value of the plant. For the first ten years, comparatively few replacements of poles will be required, but during the next two years most of the poles may have to be replaced. Thus an average amount of money equal to almost 5% of the plant investment may need to be expended each of these years for pole replacements alone, and other parts of the plant are surely and irrevocably coming to the same condition. Thus, if there has not been due regard given to a depreciation fund, or the plant is not extraordinarily prosperous, great difficulty will be encountered in obtaining the necessary money for replacements when their need begins to be acutely felt.

Few kinds of apparatus depreciate in value by equal yearly increments, but nevertheless the final effect of decrepitude or obsolescence is to eventually wipe out of the true assets of the company the value of the part less the amount saved by salvage. Such being the case, it will be readily seen that, as a piece of apparatus having a useful life of n years, for example, will be in service just n years, then each year of service will reduce its serviceableness to the owner one nth part. Its depreciation may, therefore, be based upon equal yearly increments of one nth, in determining the annual contribution that should be made toward the depreciation fund.

Therefore an annual contribution to the depreciation fund should be made such that in n years it will accumulate an amount equal to the first cost of the part installed ready for service minus the net salvage, net salvage being defined as the junk value less the cost of removing the part and preparing it for sale, that is, as the net sum recovered. But the annual contributions should draw interest at the usual trust rate for the state in which the plant is located, and the annual contribution to the depreciation account is, therefore, less than one nth of the first cost of the part. Thus, if the trust rate is 4% and n is 10 years, the actual percentage of the cost that need be set aside annually would be 8.33% of the first value of the part minus estimated net salvage. In this way the annual contribution to the depreciation fund for each part, or group of parts having the same useful life, may be determined, taking into due account the differences in life and salvage of different parts, and the sum of these several amounts gives the annual contribution to the depreciation fund for the entire plant. With this amount known, the proportion which the annual contribution to the depreciation fund has to the total cost of the plant subject to depreciation is at once available, and the percentage of annual depreciation is known.

This statement may be qualified to a certain extent by the fact that every plant will take some time to obtain a paying business, and that during this period of upbuilding it may not be expected that the earnings should cover a depreciation fund. Such being the case the annual appropriation to the depreciation fund would be omitted during this period (which should not be long) and correspondingly increased for the later years of operation.

In case of reconstruction and special insurance, the average annual amount of expenditure that is likely to occur must be determined as closely as possible in the manner already described, but here no trust interest can be considered, for, while at times the fund may show an accumulation, at other times it may be negative, so that interest received at times of accumulation may be considered as offsetting interest paid during times of borrowing.

CARE OF DEPRECIATION FUNDS.—The accumulation of these funds is for specific purposes and the money should be used only for those purposes. Also, those purposes should be supported solely from these funds. Thus, when property must be replaced on account of its depreciation, the cost of doing this (less salvage on the discarded plant) should be defrayed out of the depreciation fund, and when an underground line must be substituted for a useful overhead pole line, on account of municipal legislation, only the difference between the first costs of the underground and overhead lines should become a capital charge, and the remainder of the expenditure (less salvage) should come from the accumulated funds. It is obvious that the depreciation fund will accumulate in the earlier years after a plant has been established, because the replacements during the earlier years will be few; but after a plant is fifteen or twenty years old, the expenditures for replacements and the contributions to the funds will somewhat nearly balance when averaged over several year intervals. In all but the very largest and most comprehensive plants, the expenditures for replacements and required reconstruction will vary greatly from year to year, but the amount contributed to the fund each year should follow the computed average figure; and the sum maintained in the funds may therefore vary.

Sometimes depreciation funds are put into new plant instead of into accumulated funds. There is some question as to the advisability of this. Unless the books of a company are kept with extraordinary care, or the plant represented by the depreciation fund is kept distinct from the remainder, it is difficult to keep track of what plant represents capital investment and what represents depreciation. This difficulty is magnified, as the plant representing depreciation itself depreciates, thus introducing an additional factor that must be taken care of in the bookkeeping, and eventually the concern is likely to lose the enviable situation of having its books show the actual facts regarding its property.

It may be said that an old plant worked down to its ultimate operating condition will have an annual expenditure for replacements which remains approximately uniform, so why permit the depreciation fund to lie as a trust fund when it might be actively used in additional plant? If the depreciation fund is put into plant, the company is likely to lose its ability to show the relation of its physical property to its capital investment, and it cannot then show a true relation between earnings and the physical value of its plant. The fact cannot be ignored that the people of this country to-day expect public service companies to be in a position to show that their service is satisfactory and supplied at a reasonable cost, and it, therefore, seems necessary that such companies should be able to know their actual investment in property which represents capital invested.

The coming of public-service commissions, having power to regulate the rates of public service companies, has raised the question whether the depreciation of a plant should have an influence upon the earning power of the company. It seems patent that a company should be permitted to earn a fair return on a full, reasonable, unimpaired capitalization regardless of depreciation, so long as it supplies equally good service. This question would not seem to me to be open to doubt were it not sometimes a subject of serious discussion, and were it not that some respected publicists seem to hold that the net earning power of a public service company should be less after its plant has been subject to depreciation than when brand new, even if it gives equally good service and if the stockholders have received back no part of their invested principal, but only fair returns in interest.

With a properly conducted property, the fact that the property has suffered depreciation, which is unavoidable in any electric plant, should not have the effect of injuring the quality of its service or of impairing its capital, which would be the case if its recognized earning capacity were expected to decline proportionally with the increase of its depreciation fund. If a fair figure has been estimated for the annual contribution to the depreciation fund, this fund will always carry sufficient money to make replacements when required and, as the income from the depreciation fund is used to help build the fund, the owners of the property will not receive returns on their money twice.

There is another phase of depreciation I would like to touch upon before closing. The tendency of to-day is to make sweeping changes in plant and methods, to permit of less expensive or of improved service. On this account many excellent plants in good operating condition are shut down and the requisite power received from other sources. A company cannot well charge off of its capital account the value of such plants which may be comparatively new when they are put out of commission. In fact I have in mind a plant of 1,000-KW. capacity, which is of modern design, with steam turbine generators not over two years old, which with several other plants is being shut down owing to the possibility of obtaining power from another source at less cost than it can be produced in these plants. The question is, what should be done regarding the capital value of such plants? Unless it is necessary to retain the plants in reserve, I believe they should be dismantled and the capital of the company reduced by the amount received from the sale of discarded machinery and other property. Then the difference between the amount received from their sale and their actual capital value to the company may still be continued as a true asset of the company, and that value may be gradually charged off at the normal depreciation rate of the plants discarded, the capital of the company being reduced each year by actual liquidation of that amount. In other words, the situation is one wherein the regular depreciation appropriation is made on account of the property until the full cost of the discarded property is returned to the security holders. After this no further appropriation should be made on account of depreciation of the property concerned, as no replacements would have been made on the property, and consequently it would have been depreciated out of existence. The economies derivable from abandoning the discarded machinery should be sufficient to extinguish in this way the capital value of the abandoned plants, or else the transaction is not an advisable one.

CONCLUSION.—Where electrical properties have been failures in the past, a goodly proportion of the failures may be traced to lack of provision for depreciation and for extraordinary expenses. The reserve fund, besides covering such extraordinary expenses as are mentioned in the foregoing discussion, must be sufficient to care for losses occasioned by any recession of income which may come in the train of the physical results of the extraordinary occurrences discussed. The proper organization of a depreciation fund in conjunction with the reserve fund will also fortify a company against difficulties on account of reduced net earnings during lean years, which every company must expect, and which lean years will be offset by good years.

All will appreciate that it is impossible to figure the expenses considered in the foregoing to a high degree of exactness, but they may be figured logically and intelligently, and it may be said that a company which follows the principles here laid down regarding depreciation and reserve funds is likely to travel along an untroubled path so long as its field of operations provides sufficient earnings to warrant its existence.

Expenses and Revenues of New York Electric Railways.

Mr. E. F. Peck, Assoc. Am. Inst. E. E., General Manager of the Schenectady Ry. Co., Schenectady, N. Y., recently compiled the operating and revenue statistics of the railway companies of New York State, outside of New York City, and under the jurisdiction of the Public Service Commission, Second District. The Street Railway Association of New York sent an arrangement of these statistics to newspapers about the state and as the figures are of interest they are reprinted with slight rearrangement in the accompanying table.

EXPENSE AND OPERATING STATISTICS OF ELECTRIC RAILWAYS IN NEW YORK STATE FOR YEAR ENDING JUNE 30, 1908.

	Largest ten companies.			Seventy-four companies.		
	Total.	Per cent. of operating revenues.	Distribution of 5-ct. fares, cts.	Total.	Per cent. of operating revenues.	Distribution of 5-ct. fares, cts.
General expenses, including insurance, etc.	$934,988	06.19	0.309	$1,551,335	07.32	0.366
Cost of power	1,677,716	11.12	0.556	2,608,705	12.31	0.615
Conductors and motormen	3,217,439	21.32	1.066	4,351,391	20.53	1.027
Other transportation and traffic expenses	1,112,718	07.37	0.369	1,558,187	07.35	0.367
Maintenance of way and structures	1,187,445	07.87	0.393	1,754,505	08.28	0.414
Maintenance of equipment	941,991	06.24	0.312	1,422,599	06.71	0.336
Damages and legal expenses	734,844	04.87	0.244	884,625	04.17	0.209
Rentals	140,239	00.93	0.046	214,567	01.01	0.050
Taxes	763,290	05.06	0.253	1,046,913	04.94	0.247
Interest	2,633,101	17.45	0.873	4,270,515	20.15	1.008
Total aperating expences	$13,343,771	88.42	4.421	$19,663,342	92.77	4.639
Operating revenue	15,091,299	100.00	5.000	21,194,486	100.00	5.000
Surplus	1,747,528	11.58	0.579	1,531,144	7.23	0.361

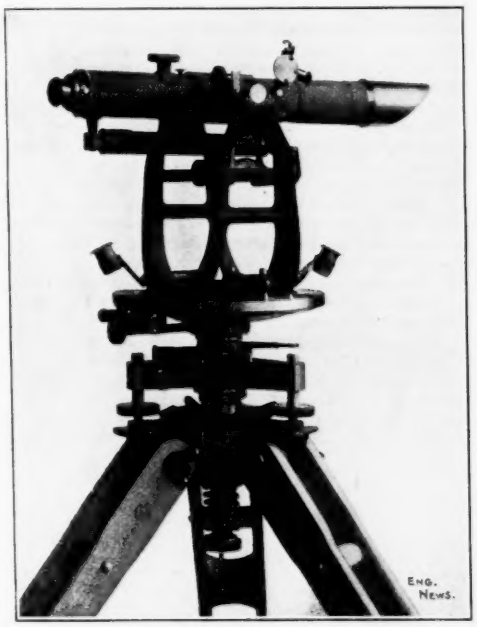
Primary Traverse Work of the Bronx Topographical Bureau, New York City.

By EDWARD H. HOLDEN,* M. Am. Soc. C. E.

Primary traverse work in New York City, where the control of the work is the United States Coast and Geodetic Survey triangulation, consists of connecting the intermediate points with the triangulation stations by traverses. The initial and closing directions of the traverses are the triangulation lines.

Primary traverse work, being the basis of all maps on which future developments depend, should be made with the utmost precision possible, and to accomplish the desired end it is essential that both the angular and lineal measurements be made, as far as possible, with the same degree of accuracy. This can only be accomplished with the best instruments and methods of use.

Of late years, the marked improvement in the manufacture of engineering instruments has made it possible for one to enjoy the benefits of a high grade instrument at a comparatively low cost. The accuracy or precision demanded



Specially Designed Transit for Use on Primary Traverse Work, Borough of The Bronx, New York City.

for any particular work, of course, determines the character and grade of instrument to be employed, but in any case the design of an instrument should aim at simplicity of construction, a proper balance of parts and an economical accomplishment of the work to be done.

There is a tendency, of late, to encumber the engineers' transit with watch telescopes, right angle telescopes, vertical arcs, etc., with the idea of getting a universal instrument. It often happens however, that the resulting instrument compares unfavorably with those which are built with a specific object in view. The simpler the working parts of an instrument the better will it do its work.

Specifications for transits or theodolites for high grade work should insist on simplicity, rigidity and proper balance of parts. A low position of the center of gravity with respect to the base, with a generous size of base is essential to the design of the best instruments. Of all the transits and theodolites used by the Topographical Bureau of New York City, covering a period of 35 years, the work done by those having the U-shaped standards and three leveling screws have proved their superiority.

With the modern methods of line measurement, an accuracy of ½-in. per mile is easily obtained and the angular measurements should be done with an allowable error not exceeding 3" per angle.

With the U-shaped transits this accuracy is easily obtained, the average error being less than 2" per angle, as the following abstracts show:

1—Strauss
2—Protectory
3—Ludlow
4—Westchester Ave. (G)
5—Morris High School
0—West Farms School

Angle.	Average of set of 6 repetitions. ° ′ ″	Average of set.	Value of seconds to close horizon.
1.0.2	51—36—42.5 51—36—36.6 51—36—39.2 51—36—41.6	51—36—39.97	40.26
2.0.3	61—25—12.5 08.83	61—25—10.66	10.95
3.0.4	44—12—08.3 08.3 06.3 07.5	44—12—07.6	07.90
4.0.5	37—46—53.30 54.55 51.50 54.90	37—46—53.56	53.85
5.0.1	164—59—06.75	164—59—06.75	07.04
	Total traverse....	359—59—58.54	
		5)1.46	
		.29"	

White Plains Road, 233d St., Eastchester Base Line and Gun Hill Road:

°	′	″
90	00	00.0
191	38	40.0
69	59	22.8
98	21	36.7
90	00	00.0
180	00	16.5
719	59	56.0

6)4.

Error of closure 0.66" per angle.

Traverse of Union Base Line, Ave. A, Westchester Ave. and Ave. E:

°	′	″
89	46	53.3
142	09	00.8
90	16	03.2
219	34	53.4
88	00	11.7
90	13	06.7
720	00	09.1

6)09.1

Error of closure 1.51" per angle.

Traverse Unionport Base Line, Ave. E, Virginia Ave. and Westchester Ave.:

°	′	″
89	46	53.3
116	11	57.4
160	01	49.1
94	21	17.4
167	38	20.5
91	59	48.3
720	00	06.0

6)06.

Error of closure 1." per angle.

Westchester Ave., Zerega Ave., Walker Ave., Washington St.:

°	′	″
127	20	23.3
91	45	58.0
89	57	09.2
140	34	00.0
90	22	30.0
540	00	00.5

5).5

Error of closure .1" per angle.

The following traverses are in the Westchester Village District:

°	′	″
52	39	36.7
132	38	34.1
190	23	53.3
118	22	02.9
137	41	50.8
88	14	02.0
719	59	39.8

6).20

.033"

°	′	″
52	39	36.7
132	38	34.1
190	23	53.3
76	53	38.3
87	24	16.6
539	59	59.0

5)1.

.2"

°	′	″
89	59	56.7
105	42	26.6
76	53	38.3
87	23	50.
359	59	51.6

4)8.4

2.1"

°	′	″
90	00	03.3
92	36	10.0
87	24	16.6
89	59	33.0
360	00	02.9

4)02.9

.7"

°	′	″
87	23	50
89	52	20
90	08	05
92	35	43.4
359	59	58.4

4)01.6

.4"

These traverses are involved one with another and are in the developed part of Westchester Village where conditions in the matter of traffic disturbance and interruption were not the best, and yet the results prove, beyond doubt, that an accuracy of 2" per angle can be secured with proper instruments, methods and observers. Better results are obtained when the instruments are placed directly on the ground than where the observations are made from triangulation towers where the twist of the stations, winds, refraction, etc., are to be contended with. These are conditions which affect the work of good and bad instruments, and good and bad observers, with this distinction that with the best instruments, observers and methods, errors due to these conditions are detected and, once known to exist, can be studied and eliminated, whereas with lower grade instruments they are not detected and therefore not properly classified and not eliminated.

The specifications for the U-shaped transit-theodolite (furnished by the firm of Keuffel & Esser) used on the work, were as follows: (See accompanying figure.) Transit-theodolite (3 leveling screws), U-shaped standards mounting the telescope to be of one piece and provided with ribs for lateral strength, and to rest directly on the top flange of the inner center. On top of each bearing of the telescope axis is mounted, a cap provided with an adjusting screw, regulating the friction of revolving telescope. These caps are to be removable readily for reversion of telescope over the bearings, caps to be arranged to exclude dust, etc. Adjustment for movement of telescope in vertical plane to be supplied in its most approved form. The bearing surfaces of telescope axis to be large and bearings of standard supporting telescope axis to be of the U-shaped order and as per direction. Vertical clamp with slow motion screw to be supplied for telescope axis. The leveling screws to be of the large pattern.

Telescope—11 in. focal length, inverting 1¼ in. clear aperture, power 24 diameters. Horizontal plate—6¼ in., graduation on solid silver, two verniers reading to 20". To be of most improved lenses and of the highest standard. Split leg tripod of usual form.

Workmanship to be the best and fully up to the standard instruments now in use in the Topographical Bureau, Borough of The Bronx.

This design of transit-theodolite is specially good for alinement, as the large base insures the stability necessary for reversal of the telescope. In the triangulation work, it was desirable to place towers directly on the northern city line. The three stations, i.e., City Line West, City Line East and Copper Bolt, were accordingly set on this line. The triangulation survey conducted by the United States Coast and Geodetic Survey, verified the correctness of the alinement, the actual corrective error being 0.001-in. to be applied to end station and being much less at the middle station. This clearly proves that with proper instruments, methods and observers, angles can be measured with an average accuracy of 2" per angle and long lines can be established by direct sighting and reversal with an accuracy at least equal to, if not greater, than the angular measurements.

In Engineering News, Dec. 24, 1908, p. 715, was an article by the writer on "A New Precise Method for Lineal Measurements," with a description of the specially designed apparatus. It may be interesting to know some of the results of its application to the monumenting work of the Borough of The Bronx, New York City. The monument line of White Plains road, from Morris Park Avenue to Gun Hill Road, over two miles long, was measured with the Invar Tapes, Tape Stretchers and Line Clinometers. Stone monuments had been set from local fixtures, and their direction and distances were required in terms of the triangulation. The line eventually was to be subdivided to conform to the block distances shown on the city map or plan and a comparison of the measured length with the distance as given by the triangulation was essential to a pro rata distribution of the variation or difference. Where there is a triangulation control, the amount of the variations between the measured and triangulated distances is not so important as the precision of the measurements. Take, for instance, a section one mile square, the corners being fixed by triangulation,

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INVAR TAPE MEASUREMENT OF MONUMENT LINE OF WHITE PLAINS ROAD, FROM MORRIS PARK AVENUE TO GUN HILL ROAD.

Station.	1st Measure in ft.	2d Measure in ft.	Variation of 1st to 2d.	Average in ft.	Variation of 1st from average.	Remarks.
A—B.....	829.9844	829.9806	+0.0038	829.9825	+0.0019	
B—C.....	829.9650	829.9662	—0.0012	829.9656	—0.0006	
C—D.....	692.0831	692.0903	—0.0072	692.0867	—0.0036	Distance established by U. S. C. and G. S.
D—E.....	1,618.2919	1,618.2931	—0.0012	1,618.2925	—0.0006	Triangulation,
E—F.....	1,243.7304	1,243.7387	—0.0083	1,243.7346	—0.0042	11,474.2031
F—G.....	6,777.5975	6,777.5670	+0.0305	6,777.5822	+0.0152	517.5791
A—G.....	11,991.6523	11,991.6359	Effective variation +0.0164	11,991.6441	Effective variation +0.0082	11,991.7822 11,991.6441 00.1381 or an error of 1 in 87,000

A = Morris Park Avenue.
B = Rhinelander Avenue.
C = Neil Avenue.
D = Bear Swamp Road.
E = Old Boston Road.
F = Pelham Parkway.
G = Gun Hill Road.

COST OF LINEAL MEASUREMENTS.

	Time per mile.	Field force.	Cost of field work.	*Cost including calculations for grade & temperature.
Invar tapes and line clinometers.....	2 hrs. 38 min.	5	$8.46	$11.26
Invar tapes and portable tripods.....	2 hrs. 12 min.	8	11.46	14.06
50-ft. spring balance tapes.....	5 hrs. 17 min.	4	13.93	13.93

*In the first two methods, measurements are taken on the natural slope of the ground and must be reduced to level and to a normal temperature; in the last method the field measurements are level and the tape length is adjusted to temperature as the work proceeds so that no reduction is necessary.

unless the field measurements of the four sides are made with equal precision, and the variations adjusted to the triangulation length and the intermediate points made consistent with the adjustments one cannot expect the monumenting of that section to conform to the triangulation. If the intermediate points are not set by the accurate method of determining the variations the angles developed will not be consistent with the triangulation or the city map. In this work the idea is not to see how well the triangulation has been done, but to obtain some accurate and reliable means of determining the positions of intermediate points between the triangulation stations which will be consistent with the triangulation.

A great advantage of the precise method of measures lies in the fact that a monument originally set and subsequently disturbed can always be replaced in the exact position it originally held.

The following abstract shows the result of two measurements with their variations, average and variations from the average. The line was divided in sections, each being measured in duplicate, once forward and once backward. The remarkable agreement of the totals is due to the balancing errors of the partials. The terminals of the line were determined by the triangulation stations Protectory and Briggs, the length by triangulation being 11,991.782 ft. against Invar tape measurement of 11,991.644 ft. In other words the Invar tape measure agrees with the triangulation length within an accuracy of one part in 87,000, which is three times the accuracy called for in the triangulation itself.

The accompanying tabulation shows the comparative speed and cost, per mile, of lineal measurements by the different methods.

For a limited time, the speed of the third method can be increased over that given but experience proves that it can not be maintained. The relative value for accuracy or precision is about the same for the first two methods and is from 16 to 32 times greater than that for third method, the use of plumb bobs and the unreliability of the thermometer being the principal undesirable factors.

With the Invar tapes replacing the steel ones and improved methods of line measurements, and with the angles measured in the manner herein set forth, we have a fairly even balance between the lineal and angular work, each holding the other down to small errors and thus affording a good criterion for the accuracy of the work.

Curved Masonry Dams in New South Wales.*

By L. A. B. WADE,† M. Inst. C. E.

In providing water supplies for towns in New South Wales thirteen dams have been built curved in plan, reliance for stability being placed only on the capacity of the material in the wall and sides of the valley to resist compression. In designing these dams the complex question of the exact stresses that may occur and the assistance that may be afforded by the weight of the wall has been disregarded; as it has been considered that all practical requirements would be met if in theory the dams were treated simply as sections of rigid cylinders subject to exterior water-pressure.

The formulas used for determining the widths of a wall at different levels below the highest water-surface are deduced from the expression.

$$T = \frac{R\,P}{S}$$

Where T denotes the thickness at any level in ft.
R denotes the radius in ft.
P denotes the water-pressure in tons per sq. ft.
S denotes the stress in tons per sq. ft.

The widths vary as follows, according to the limiting stresses allowed for different materials—

If D denotes the depth of water in feet,
Then T is equal to $R\,D \times 0.0014$ when S is 20 tons.
T is equal to $R\,D \times 0.0018$ when S is 15 tons.
T is equal to $R\,D \times 0.0023$ when S is 12 tons.
T is equal to $R\,D \times 0.0027$ when S is 10 tons.

The theoretical cross-section would then be represented by a triangle, having its apex at the highest overflow-level of the water-surface. Usually in practice it has been found advisable to make the top thickness of the wall not less than 3 ft. 6 ins.; this thickness being increased according to the depth of water and the weight of timber passing over the crest in flood-time. The climatic conditions of New South Wales are such that stresses resulting from the formation of heavy ice need not be provided for. In all of the thirteen cases it has been found convenient to pass flood-waters over a portion of the length of the wall; a maximum depth of 3 ft. has been thus dealt with at Parkes, where the crest width is 3 ft. only, without any bad results following. The top thickness being determined, the wall for a short distance from the top is carried down vertically, and is then eased by an intermediate batter into the theoretical profile.

It will be seen by the accompanying figures that three different types of cross-section have been used:

1. A wall having similar profiles on both its up-stream and down-stream faces, so that the center of gravity of all layers is in a vertical line in the center of the wall. (Parkes dam, Fig. 3.)

2. A wall battered on the up-stream face, with a vertical down-stream face, additional stability being afforded in theory by the downward pressure of water on the up-stream face. (Tamworth dam, Fig. 3, and Cootamundra dam, Figs. 1-2.)

3. A wall battered on the down-stream face, and with a vertical up-stream face. (All dams in figures except those mentioned above.)

Practical considerations have caused the abandonment of Types 1 and 2 and the final adoption of Type 3, as it affords greater facilities for the handling of the swivel-jointed type of draw-off pipe that is used. The radii used in the calculations were measured to the center of gravity of the wall in Type 1 and to the vertical faces of the walls in Types 2 and 3.

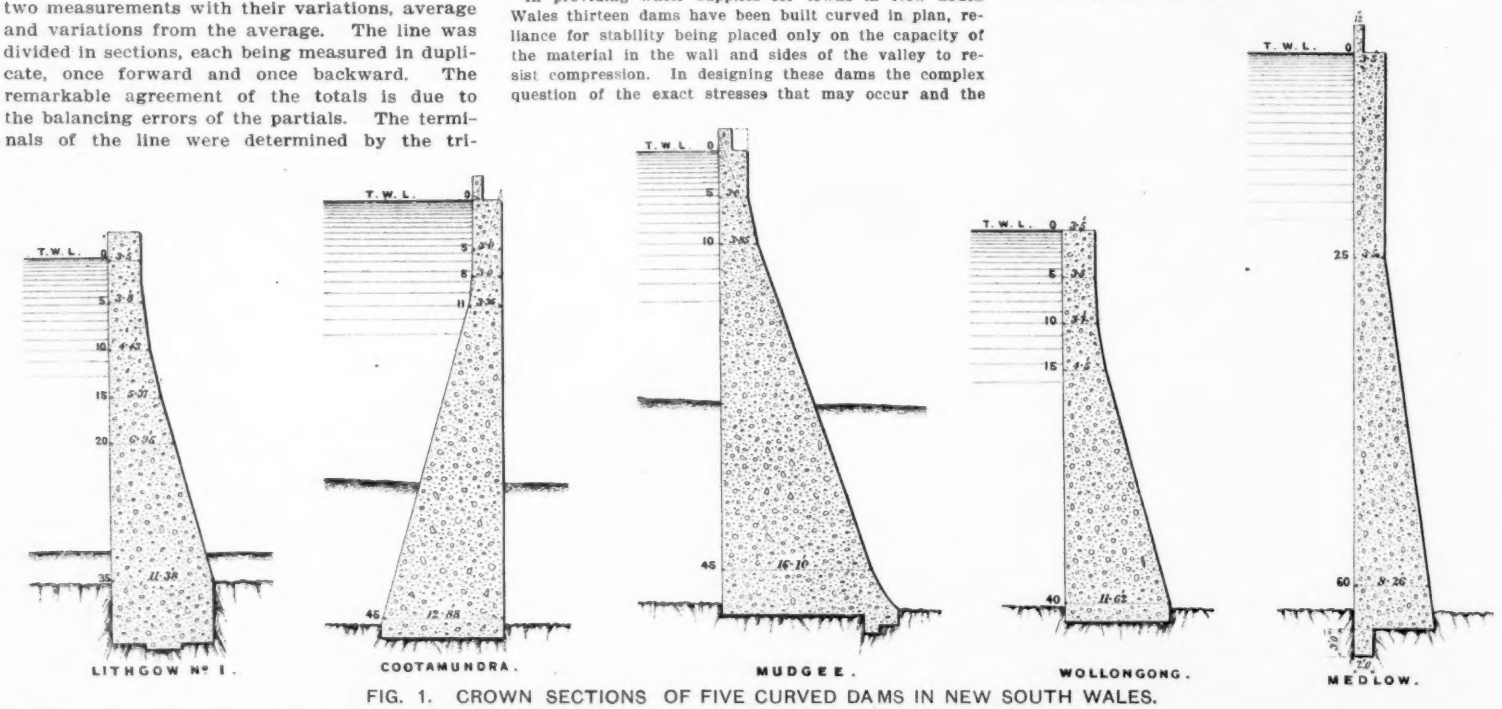


FIG. 1. CROWN SECTIONS OF FIVE CURVED DAMS IN NEW SOUTH WALES.

Nine of the thirteen walls are curved on plan over their whole length and abut against the rock sides of the gorges up to their top levels; while of the remainder the Cootamundra dam has been constructed with two tangents of gravity cross section, and the Tamworth, Parkes and Wollongong walls each with one tangent of gravity cross section. The Cootamundra, Tamworth and Wollongong gravity tangents abut against the rock sides of the gorges to their top levels. The gravity tangent at Parkes is constructed on a flat bench of rock at a level of about 13 ft. below the top of the wall, and the

*From a paper "Concrete and Masonry Dam Construction in New South Wales," presented before the Institution of Civil Engineers.

†Chief Engineer for Rivers, Water Supply and Drainage, Public Works Department, N. S. W., Sydney, N. S. W.

TABLE SHOWING DETAILS OF CURVED MASONRY DAMS BUILT BY THE PUBLIC WORKS DEPARTMENT OF NEW SOUTH WALES.

Locality.	Maximum height above foundation, ft.	Total length, ft.	Top thickness, ft.	Depth below crest of top thickness, ft.	Thickness of base, ft.	Surcharge allowed for, ft.	Radius of curved part, ft.	Limit of pressure in tons* per sq. ft.	Approximate storage. Imp. gals.	Character of rock forming site and used in construction.	Date of construction.	Remarks.
Parramatta	52.0	225	4.8	0	15.0	2.0	160	16.8	130,000,000	Sandstone	....	Original height 41 ft. of masonry in Roman cement, built in 1858, raised to 52 ft. with concrete in 1898.
Lithgow No. 1	35.0	178	3.5	3.5	10.88	3.5	100	11.2	15,000,000	Sandstone	1896	
Parkes	33.5	540	3.0	6.0	13.5	5.0	300	26.9	114,000,000	Granite	1897	
Cootamundra	46.0	640	3.0	8.0	13.0	1.0	250	28.0	136,000,000	Granite	1898	
Picton	28.0	112	7.0	0	13.62	10.0	120	13.4	14,000,000	Sandstone	1897	Constructed to be raised 14 ft. when required.
Tamworth	61.0	440	3.0	3.0	21.5	2.0	250	22.4	50,000,000	Granite	1898	
Wellington	48.0	350	3.0	7.0	10.0	2.0	150	22.4	27,000,000	Conglomerate	1899	
Mudgee	50.0	498	3.0	5.0	18.0	1.0	253	22.4	42,000,000	Altered slate	1899	
Wollongong	42.0	535	3.5	5.0	11.62	1.0	200	22.4	160,000,000	Basalt	....	
Katoomba	25.0	320	3.0	7.5	20.29	1.0	220	16.8	34,000,000	Sandstone	1905	Constructed with buttresses. Ultimate height 50 ft.
Lithgow No. 2	87.0	221	3.0	3.0	24.0	3.0	100	11.2	88,000,000	Sandstone	1906	
Medlow	65.0	124	3.5	21.0	8.96	3.0	60	13.4	66,800,000	Sandstone	1906	
Queen Charlotte Vale	32.0	113	3.0	6.0	8.65	2.0	90	11.2	.....	Quartzite	1898	

*Short tons of 2,000 lbs.

thrust of the arched length is resisted by the weight of the gravity wall, assisted by an anchorage of steel rails placed vertically so as to connect the wall with the rock foundation.

It is found as a rule that the positions of the horns of the curve are more or less fixed by local conditions and that a radius giving a versed sine of about one-third of its length then forms the most economical location between those points. Occasions arise, however, when this rule will not apply, and the radius may be altered with advantage to suit the configuration of the valley. A few trial curves marked on the ground are in all cases necessary to secure the best results.

Of the thirteen walls constructed, all but four have been carried in the first instance to the full height proposed; of the remainder, those at Parramatta, Parkes and Picton were constructed to the full cross sectional widths but stopped short of the full height proposed. The Katoomba dam was constructed to the less height shown in Fig. 3, with a cross section reduced to afford the same crushing-resistance as that to be allowed in the higher wall when completed. In this case buttresses 3 ft. thick were carried to the full cross-sectional width of the proposed higher wall, being spaced 7 ft. apart, and putlog holes were left in them for the subsequent insertion of bonding iron when the wall was being carried to the full height and the spaces between the buttresses were being filled in.

The accompanying table gives the full particulars of each of the thirteen structures under review.

It will be noted that in two cases maximum pressures of 24 and 25 long* tons (26.9 and 28.0 short tons) per sq. ft. have been allowed where the material in the wall and foundations consisted of hard granite and diorite; later practice, however, has been to reduce this limit to 20 long tons (22.4 short tons) per sq. ft., which is considered to afford an ample factor of safety where sound igneous rocks are being dealt with. Hard slates, sandstones, conglomerates and ironstones are limited to pressures of 15 and 12 long tons (16.8 and 13.4 short tons) per sq. ft., according to quality, and softer sandstones to 10 long tons (11.2 short tons) per sq. ft. These limiting pressures refer more to the material used in the construction of the wall than to that met with in the abutments, as should the wall have a greater crushing resistance than the abutments, it is a simple matter to splay the wall where it meets the rock and thus to reduce the pressure per unit of area at that point. The walls have in all cases been constructed of Portland-cement concrete, with plums of selected stone having a greater resistance to crushing than the concrete surrounding them. The crushing strength of the concrete used is therefore the measure of the crushing resistance within the wall. The proportions of the concrete have in all cases been 1 cask (equal to about 4½ cu. ft.) of cement, 11½ cu. ft. of sand, 10 cu. ft. of shivers from ¾-in. to ½-in. gage and 13 cu. ft. of metal of 1½-in. gage. Samples of concrete for testing purposes have been taken from time to time from the mixings used in the work and have been tested for crushing strength over various ages. The results obtained from a number of tests of 6-in. cubes, 6 months old and crushed unsupported in a testing machine, have been utilized to fix an average standard strength for concrete made of the different classes of rock dealt with. These results give a mean crushing resistance ranging from 50 long tons (56 short tons) per sq. ft. for the soft sandstone to 100 long tons (112 short tons) per sq. ft. for the sound igneous rocks. It has been assumed that concrete in bulk offers a crushing resistance 50% greater than in the unsupported 6-in. cubes. The maximum theoretical pressures allowed in the construction of the walls have been adjusted to give a factor of safety of 5 on the basis of results obtained from unsupported concrete cubes; and if the assumption as to increased strength is correct, the factor will be 7½ for concrete in bulk.

The cross section of a curved wall 500 ft. in radius and calculated to resist a stress of 20 long tons (22.4 short tons) per sq. ft., or of a curved wall of 270 ft. radius to resist a stress of 10 long tons (11.2 short tons) per sq. ft., closely approximates to the cross section of a gravity wall designed to retain a similar depth of water. The author is of opinion that gravity walls in narrow gorges should be constructed straight on plan, the employment of a curve presenting no advantages—as regards either additional strength, elimination of tensional strains or adaptability to meet contraction—sufficient to justify the extra cost involved by the increased quantities. The economical limit where it will be justifiable to substitute curved walls such as those described, for gravity walls will then be with radii rather less than these, bearing in mind the additional quantities involved by the greater length of the curved wall over the straight one. It will be seen that the use of curved walls is thus restricted to comparatively narrow valleys and gorges.

FOUNDATIONS AND ABUTMENTS.—The igneous rocks met with in the construction of these works afforded not only the best foundations, but also the most impervious media to leakage under their foundations. It was necessary, however, particularly with granite, to exercise great care in following out all soft seams, which at times were found liable to develop into serious faults. In sandstones and conglomerates the weakness as a rule was found along horizontal beds, and in several cases leakages took place under the flanks of the wall, the water entering some distance up-stream and the exit being some distance down-stream of the wall. In two instances short drives have been carried under the flank of a wall to cut out weak horizontal joints and fissures in the rock; the drives were filled with concrete, and finally grouted up solid under pressure, holes being drilled to the top of the concrete for this purpose. The worst leakages have been experienced in shale and slate,

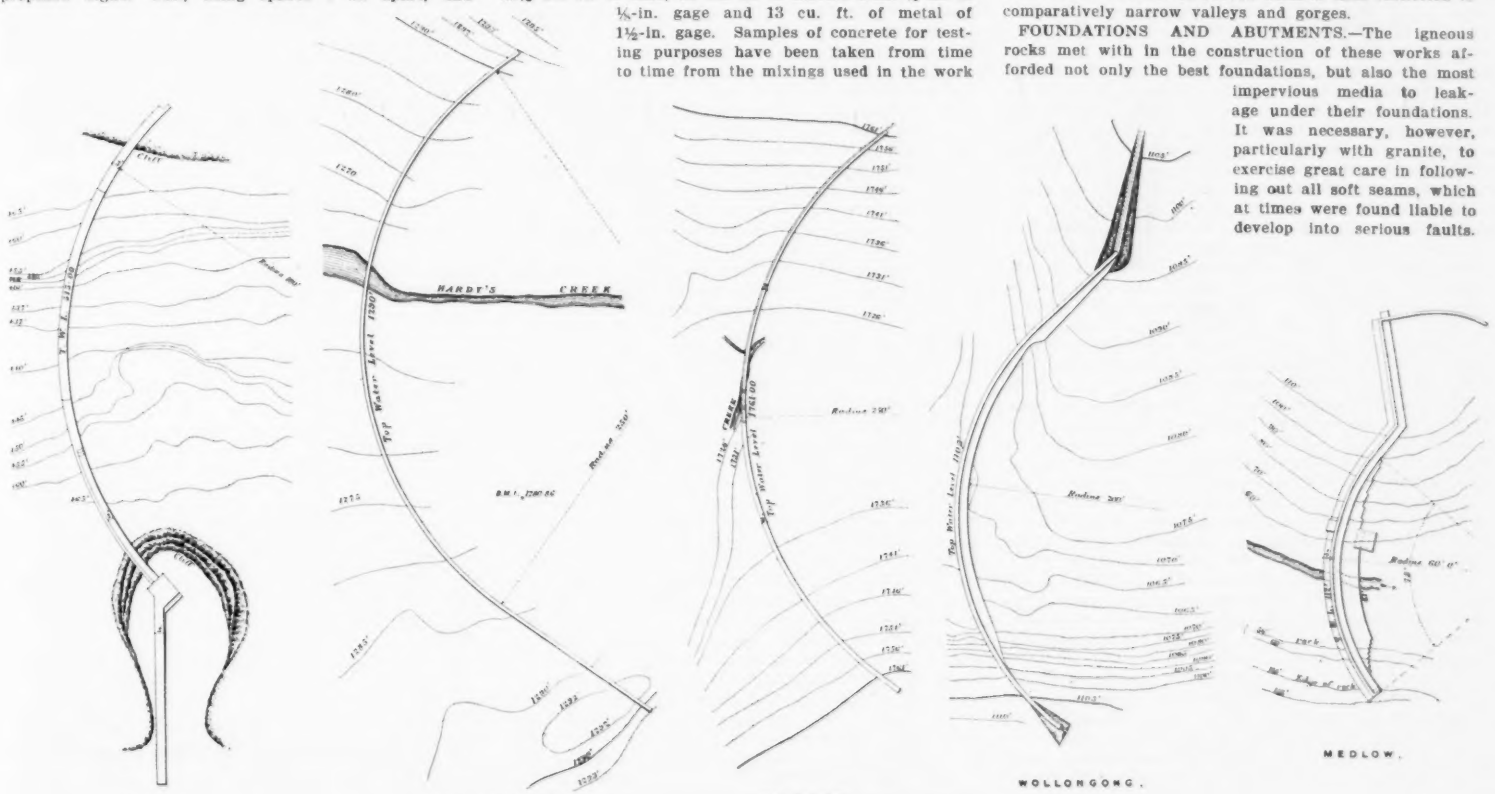
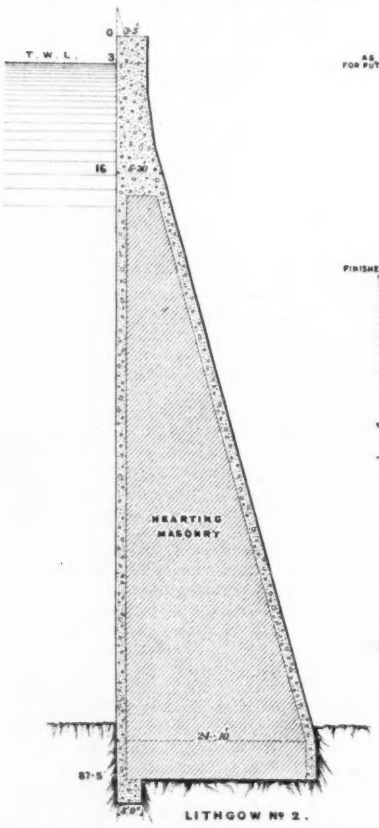


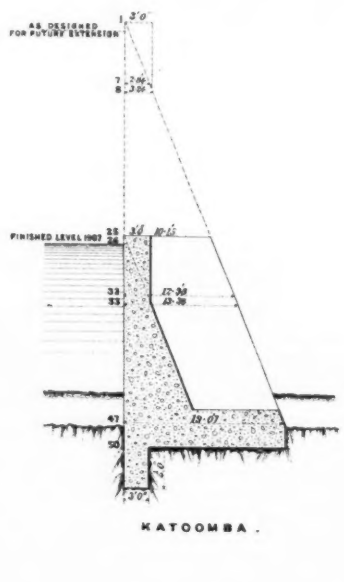
FIG. 2. PLANS OF THE FIVE CURVED DAMS SHOWN IN FIG. 1.

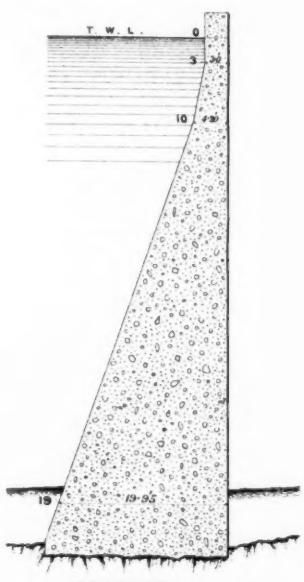
*Long tons in this article means the English ton of 2,240 lbs. The short ton is the 2,000-lb. ton.—Ed. Eng. News.

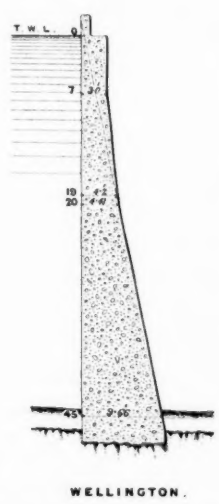
particularly where the formation has been disturbed and the beds do not lie horizontally.

In preparing rock foundations to receive the wall, it has not generally been found necessary to cut out skewbacks. It is found as a rule that the harder igneous rocks require very little preparation and that in their natural state the surfaces are sufficiently irregular to form a key; where the surfaces are flat or smooth a few "pop" shots will afford the required key. When using









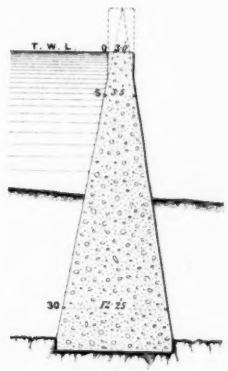


FIG. 3. CROWN SECTIONS OF FIVE OTHER CURVED DAMS IN NEW SOUTH WALES.

even small pops, however, care must be taken, as the sting of the shot results in minute cracks which weaken the adjacent rock. In the sedimentary rocks, where the surfaces are more or less soft and weathered, skewbacks are provided to a greater extent than in the igneous rocks. A similar practice prevails in regard to cut-off trenches under the foundations. The surfaces of the harder igneous rocks are first of all well washed with a jet of water under pressure; they are then grouted and a ½-in. layer of good mortar is applied before placing the concrete; this as a rule renders the surface sufficiently rough to afford a good connection and to prevent leakage under the base of the wall. In the softer sedimentary rocks, however, it is usual to channel a shallow trench for the reception of a cut-off wall. The curved wall has an advantage over the straight wall, inasmuch as its stability is not endangered to the same extent by small leakages occurring between its base and the foundations.

COMPOSITION OF CONCRETE.—The proportions of the materials in the concrete used are sufficient to afford the required resistance against crushing at the minimum cost, but when placed in a thin wall they do not form an impervious medium against the passage of water under pressure. In the earlier walls constructed, a 6-in. layer of special concrete was placed on the up-stream face to secure watertightness. Subsequent experience proved that watertightness could be more effectually and economically secured by the formation of a skin of neat cement on the up-stream and down-stream faces of the wall. In practice it was found that if sloppy concrete was used and was well cut and worked against the forms, a skin of cement was formed at the surface, and a practically impervious wall was obtained. When, however, the surplus moisture dried out, longitudinal contraction, with the development of a number of vertical cracks, took place. Further experience demonstrated that longitudinal contraction is much less in a wall constructed of concrete placed in position fairly dry and well rammed, and that under such conditions vertical cracks either do not occur or occur only in a less degree. A skin, however, could not be obtained under such conditions, and the thin walls so built were found to leak excessively. Experiments were carried out to ascertain the best means of securing a watertight wall by painting the faces, and it was found that two coats of neat cement applied with a hard brush to the green concrete, immediately after the timber was stripped, gave the best results. The practice now adopted is to construct the walls of concrete mixed with a minimum quantity of water and well rammed and cut against the forms; two coats of neat cement are then applied to the up-stream and down-stream faces immediately after the forms have been removed and while the concrete is green and moist. This system of construction has yielded excellent results under the climatic conditions of New South Wales, but the application of the neat cement coating is not recommended where the walls would be subject to the influence of many degrees of frost, as scaling then results. A facing of richer concrete under these latter conditions is preferable.

In order to reduce the cost of concrete, plums have been used in the walls where the cross sections are of sufficient width to allow it to be done. With the exception of such a wall as Lithgow No. 2 (Fig. 3), where the quantities to be dealt with justified the installation of plant to handle large stones, the plums have been of a maximum size that could be handled by two men. By this method it has been found that 30% of plums can be advantageously inserted where the stone is rough from the quarry and the pieces are of irregular dimensions with no work done in squaring. Any large proportion of such stone is liable to result in inefficient packing of the concrete around them. When stone with natural beds, such as can be quarried of fairly square dimensions, is available, this proportion may be slightly increased. It is necessary to use concrete in a fairly sloppy condition to secure satisfactory bedding of the plums, as when concrete is used so dry that plums cannot be sunk and worked in, it has been found that in most cases air-spaces exist under them. There is also a tendency in working with a dry concrete to place plums in horizontal layers, which, combined with inefficient bedding, would form horizontal lines of cleavage. The author considers that for the purpose of avoiding contraction and shrinkage, with resulting vertical cracking, the desirability of using concrete mixed with as little water as practicable is unquestionable; and that if plums are then used, it is necessary for them to be embedded in mortar. Where the stones used have naturally flat beds the proportionate quantity of mortar required will not be large and the use of plums will reduce the cost of the wall; but, where stones are irregularly shaped and the quantities in the wall are such that the installation of machinery for handling large stones is not justified, it is doubtful, having regard to the cost of labor and Portland cement in the state, whether the use of plums of small dimensions with mortar beds is more economical than the use of concrete only.

CRACKS IN DAMS.—A danger more apparent than real in dam-walls which rely upon their curvature for stability is the occurrence of vertical cracks; such cracks have appeared more or less in five of the longest of the thirteen structures under review, but no failures have resulted. All these structures have been kept under observation since their completion, and an inspection at the end of the summer of 1908 showed their individual conditions to be as follows:

Parkes Dam (Fig 3).—A vertical crack from top to base near the deepest portion of the wall. A horizontal crack 35 ft. in length in the right wing of the dam, at the level where the change of cross section from vertical to battered faces takes place. Leakage through cracks slight. (Constructed of dry concrete and plums.)

Cootamundra Dam (Figs. 1-2).—A vertical crack in the straight gravity tangent extending from the top to halfway down. A vertical crack in the curved portion of the wall from the top to 8 ft. down. Leakage through cracks very slight. (Constructed of dry concrete and plums.)

Tamworth Dam (Fig. 3).—A vertical crack in the curved portion at 43 ft. from the abutment, extending from top to base. Very slight leakage. (Constructed of dry concrete and plums.)

Wellington Dam (Fig. 3).—Eight vertical cracks extending from 8 to 12 ft. down from the top. Leakage very slight. (Constructed of dry concrete and plums.)

Mudgee Dam (Figs. 1-2).—Seven vertical cracks extending from top to base, an average distance of 54 ft. apart. Leakage slight. (Constructed of sloppy concrete and plums.)

No vertical or horizontal cracks exist in any of the other walls.

It will be seen that the largest number of cracks have occurred in the Mudgee wall, constructed of sloppy concrete with a view, at the time, of working up a watertight skin on the faces. The cracks in this wall, in addition to being more numerous, are deeper and more open than those in any of the walls constructed of dry concrete. None of the vertical cracks which have occurred in the walls follow radial lines, nor as a rule do they go down in a vertical plane, but twist in their course. The vertical cracks are in all cases due to both shrinkage from drying-out of the water with which the concrete has been mixed, and contraction as the result of low temperature. When once formed, they close and open with

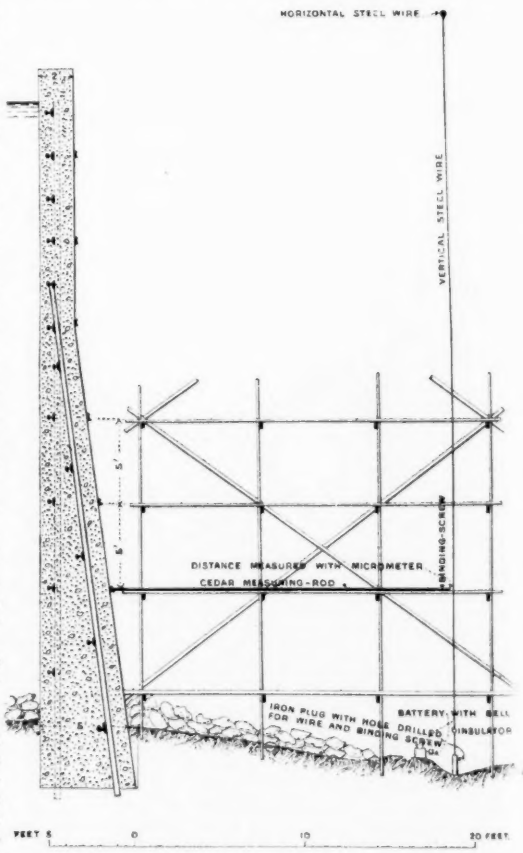

HORIZONTAL STEEL WIRE
VERTICAL STEEL WIRE
DISTANCE MEASURED WITH MICROMETER CEDAR MEASURING-ROD
BINDING-SCREW
IRON PLUG WITH HOLE DRILLED FOR WIRE AND BINDING SCREW
BATTERY WITH BELL
INSULATOR
FEET 5 0 10 20 FEET

Fig. 4. Section Through Auxiliary Curved Dam for Barren Jack Reservoir, N. S. W., Showing Method of Measuring Movements.

changes of temperatures and with the absorption or loss of moisture by the concrete. They almost disappear in the hot periods of summer when water-levels are low and in the cold periods of winter when water-levels are high, showing their maximum opening if water-levels are low in the cold period of the winter. They occur as a rule at points where there are quick changes in the foundation-levels, but are not confined to such places. The author is of opinion that vertical cracks may be expected to occur in the top levels of long, thin, curved walls such as those described, and that such cracks, since they occur naturally, do not endanger the stability of the walls. Seeing, however, that they are liable to develop, it is better to provide parting joints, to allow of the cracks forming on radial lines spaced at intervals, than to allow them to occur naturally. The building of iron horizontally into the top levels of the walls has been suggested as a means of preventing vertical cracks, but the author considers that this step would probably lead to the occurrence of longitudinal cracks. It might, however, be advisable thus to build in iron if the parting joints suggested were provided, and the iron did not cross these joints.

Observations of the Cootamundra wall, made before any water had been stored behind it or any vertical cracks had developed, showed a maximum movement in the center of ¾-in. on a radial line. Observations were made in connection with some of the other walls, but no similar movement was noted, probably because the dams then stored large bodies of water and the conditions were constant.

SLUICE PIPES.—The provisions made for passing water through the walls during construction, and for

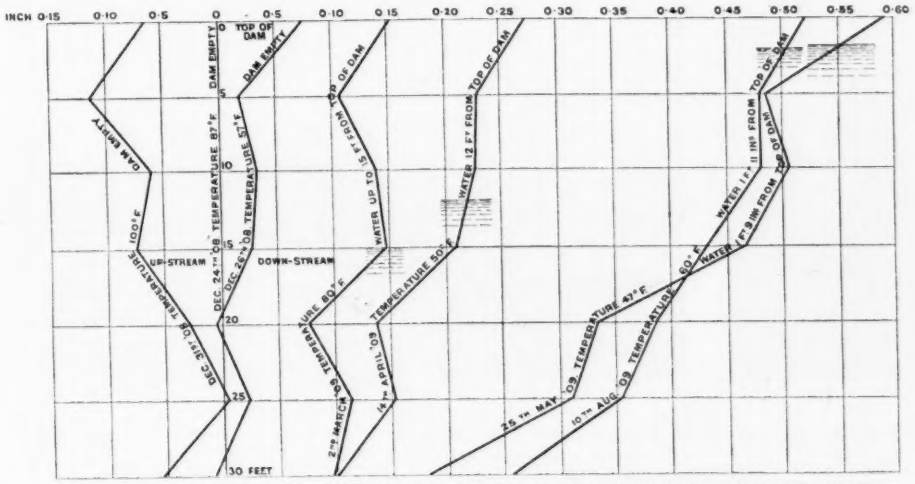

INCH 0·15 0·10 0·5 0 0·5 0·10 0·15 0·20 0·25 0·30 0·35 0·40 0·45 0·50 0·55 0·60
TOP OF DAM
DAM EMPTY
DAM EMPTY
TOP OF DAM
WATER 12 FT FROM TOP OF DAM
WATER 11 FT 11 INS FROM TOP OF DAM
DAM EMPTY
TEMPERATURE 100° F
UP-STREAM
DOWN-STREAM
DEC 24TH '08 TEMPERATURE 87°F
DEC 26TH '08 TEMPERATURE 57°F
WATER UP TO 15 FEET FROM TOP OF DAM
TEMPERATURE 80° F
TEMPERATURE 50° F
TEMPERATURE 47° F
TEMPERATURE 50° F
WATER 12 FT FROM TOP OF DAM
2ND MARCH '09
14TH APRIL '09
25TH MAY '09
10TH AUG '09
30 FEET

FIG. 5. DIAGRAM OF MOVEMENT OF BARREN JACK RESERVOIR AUXILIARY DAM.

scouring and drawing-off purposes after completion, usually consist of a 24-in. cast-iron scour-pipe controlled on the outside of the wall by a single-faced sluice-valve. The valve is protected by an arched concrete hood, and access to the top of the hood is obtained from the top of the wall by step-irons placed on the down-stream side of the wall. Repairs to sluice-valves have been effected when water was retained to its full depth behind the wall, access being afforded by closing the bell-mouth of the pipe with a wooden door lowered into position from the top. For supply purposes, a cast-iron pipe of larger diameter than the proposed main is built into the wall with a trunnion joint on the inner side, and two branches on the outer side. A wrought-iron galvanized pipe with a wire-netting screen over the inlet-end is connected to the trunnion joint and is raised or lowered by means of a crab-winch, which is fixed on the top of the wall and worked from a platform of wrought iron brackets. This pipe is worked in a plane radial to the curve of the wall and is of sufficient length to enable supplies to be drawn from near the surface of the stored water.

The construction of these walls has been carried out both by contractors and by day labor under the officers of the department. The most satisfactory way that has been found, however, is to lay bare the foundations by the latter method and then to build the wall by contract, the department supplying all cement and the contractor providing only labor and plant. By this plan most of the risks to which a contractor is liable are eliminated, economy is obtained in the management of labor, and the quality of the work is guaranteed so far as the quantity of cement used is concerned. The Lithgow No. 2 wall was the only dam of sufficient magnitude to justify the installation of plant for handling large blocks of stone. The usual plant provided on the smaller works consists only of a portable engine and a stone crusher to break the metal for concrete. All concrete is mixed by hand above the levels where it is to be used and is wheeled into place in barrows or trucks. The "gravity" type of concrete mixer, consisting of a chute slightly inclined from the vertical and fitted with staggered rows of pins, is sometimes used where levels permit; but the materials are thoroughly mixed dry before being cast down, and the mixer is only used in lieu of the wet turnings, water added to the materials during their passage downwards. The wall is then built up in 3-ft. courses, fairly dry concrete being placed in 12-in. layers and rammed until water appears on the surface.

CONCLUSIONS.—In the author's opinion, the experience gained with these structures since the first was completed in 1895 shows:

That curved walls relying for stability on their resistance to crushing form a safe and economical means of storing large bodies of water.

That such walls may be safely treated theoretically as rigid cylinders subject to outside water-pressure, provided the limiting stresses are adjusted to give a factor of safety of 5 for the various classes of materials used.

That it is desirable to provide parting joints to secure that any cracks occurring may be radial to the curve.

That where it is economical to do so, it is admissible to use tangential lengths of gravity wall in order to obtain a curve of short radius.

That the minimum thickness of wall should be not less than 3 ft. 6 ins.

That concrete should be placed in situ as dry as practicable and well rammed, and if plum-stones are used they should be embedded in mortar.

Mr. C. W. Darley, M. Inst. C. E., then Engineer-in-Chief for Public Works, was responsible for the initiation of this type of dam, and for the construction of the earlier structures. The author acted under Mr. Darley as supervising engineer over these works, and, subsequently succeeding him, was responsible for the design and construction of the Lithgow No. 2, Katoomba and Medlow dams.

[From the very voluminous discussion that followed Mr. Wade's paper, we have selected the following extracts by Messrs. Darley and De Burgh, each of whom was connected with the work in New South Wales, as bearing particularly on the behavior of the dams that he described.—Ed. Eng. News.]

These five dams in which cracks are described were constructed under extreme conditions. They all happened to be built during a period of drought, with the temperature at 100° F. and often more. It was of course expected that rain would fall in the following season, immediately after the hot weather, and that the reservoirs would be filled. Unfortunately rain failed that year, and the dams stood empty in the dry and very cold winter that followed, with a good deal of ice about, some of it probably 2 ins. thick, on what water there happened to be. In the Tamworth dam there was a crack ⅜-in. wide, running from the top nearly to the bottom. Some of the engineers were alarmed and recommended grouting, but the chief engineer refused to have grouting done and ordered the crack to be covered so that nothing could get into it, believing that as the water rose the crack would close. When rain came the cracks were closed, with no indication of weeping; indeed it was impossible for anybody who had not seen the crack to say what part of the wall it was in. The wall was damp, but there was no leakage to speak of: not a gallon per hour passed through the whole wall, so that practically it was watertight. Later on it got still tighter, all the pores becoming closed. To some extent the cracks breathed; if the water was low in cold weather they would open above in the dry portion.

In connection with the supply of water for domestic purposes to the workmen employed on the construction of the great dam at Barren Jack, a curved concrete dam (Fig. 4) had been erected on Barren Jack Creek 38 ft. in height, 80 ft. in radius, 2 ft. thick at the top, 5 ft. at the bottom; the compression stress as calculated by the formula given by Mr. Wade was 17 long tons (19 short tons) per sq. ft. While there was no necessity to introduce reinforcement, a quantity of 20-lb. rails on hand had been placed in the dam with a view to observe the effect. The concrete used in the work was mixed in the proportions of 375 lbs. of cement, 12 cu. ft. of sand and 20 cu. ft. of stone broken to 2½-in. gage. The steel rails were placed vertically, 10 ft. apart, within the dam and 1 ft. from the up-stream face, their lower ends being let into the solid rock. Rails were also placed 10 ft. apart, but alternating with these 1 ft. from the down-stream face. These latter, however, were only carried up until they intersected the line of the up-stream rail. Such rails as were not long enough to reach to the top of the dam were lengthened by having others fixed to them. Other similar rails curved to the radius of the dam were then placed horizontally and secured on the up-stream side of the vertical rails; a line of these horizontal rails was put in at every 2 ft. 6 ins. in the height of the dam, the up-stream and down-stream rows alternating. The dam was completed in December, 1908, when it was given one coat of cement wash.

At that time the creek had stopped running and there was no water in the reservoir. In order to ascertain what movements took place in the dam under variations of pressure and temperature, metal plugs were fixed centrally in the concrete of the down-stream face at each 5-ft. level, measured from the top. A steel wire, No. 16, S. W. G., was securely fixed on the left bank and passed over pulleys grooved to receive it on the right bank, where it was strained by a 200-lb. weight. In plan this wire was 20 ft. from the down-stream face of the dam, and to it was fixed (by means of a suitable clamp) a No. 31 steel wire, strained and securely fixed to the rock vertically under the top connection. The horizontal distances between the plugs in the dam and the vertical wire were then measured, and any variation in these measurements would indicate the movement of the wall. The method of measuring was the following: A staging was erected between the dam and the vertical wire, with a platform on a level with each metal plug. The measurements were taken with cedar measuring-rods slightly shorter than the distance between the metal plugs and the vertical wire; these rods were shod with knife-edges of metal. One knife-edge was placed against the metal plug in the concrete and the rod was supported horizontally on the platform with the other end in line with the vertical wire. The vertical wire was connected with one pole of a battery through an electric bell, the other pole being connected with the metal shoe at the end of the measuring-rod, and the distance was then measured with a micrometer, placed against the end of the metal shoe. When the micrometer touched the vertical wire the circuit was completed and the bell rang. By this means the movements of the dam could be measured with a fair degree of accuracy.

Measurements were taken first with the dam empty on Dec. 24, 1908, temperature 87° F.; Dec. 26, 1908, empty, temperature 57° F.; Dec. 31, 1908, empty, temperature 100° F.; March 2, 1909, water 15 ft. from top, temperature 80° F.; April 14, 1909, water 12 ft. from top, temperature 50° F. The movements thus obtained are shown to a distorted scale in Fig. 5. It will be seen that the maximum movement up-stream with change of temperature is 0.115-in., and down-stream with decreased temperature 0.076-in., while with a decrease of 7° and water up to 15 ft. from the top of the dam the maximum movement is 0.152-in. This is increased to 0.272-in., with the temperature at 50° and with water up to 12 ft. from the top. Since then the dam has been filled, and the water has been running over the by-wash to a depth of 3 to 15 ins. The deflections read with the dam full are also plotted in Fig. 5. The fact that the left abutment of this dam runs into the solid rock up to the level of the crest, while the stress of the right abutment for the upper 10 ft. is distributed into the rock by means of a concrete abutment and a wing-wall, might have a certain effect upon the deflections in the upper 10 ft.

There is, however, nothing to show that any yield has taken place, and until the dam is again empty it cannot be stated how much, if any, of the deflection shown is permanent. It might be mentioned, however, that up to August, 1909, there was no leakage through the dam, and only a slight uniform appearance of moisture on the face of the dam up to water-level. The dam is behaving satisfactorily in every way. The method of measuring the deflection is admittedly a primitive one, but it is not easy to devise a better means by which any very exact measurement might be taken without incurring heavy expense.

A HATCH COVER AND SHIP HULL has been recently designed by Mr. Jos. R. Oldham, of Cleveland, Ohio, intended for use on vessels carrying bulk freight, particularly ore. The hatch cover is of steel plates and when it is to be removed it is slid to one side and goes down into a chamber between the outer plating of the hull and an inner skin. This inner skin is made continuous and water-tight so that additional safety is secured for the vessel in case of leakage through the outer hull in case of grounding. The invention is covered by U. S. Patent No. 956,152.

A Four-Wheeled Scraper of Large Capacity for Excavation and Grading.

The wheeled-scraper is one of the most extensively used machines for earthwork involving comparatively short hauls (up to about 1,000 ft.), as the one machine does the work of excavating, hauling and depositing, so there is no rehandling of the material. The machine has an advantage also in its flexibility of movement, as it can take material from and deposit it at any desired point. These features were reviewed in an article on "Machinery for Canal and Ditch Excavation" in our issue of Aug. 26, 1909. The ordinary machine has a single axle and pair of wheels, with a steel pan or scraper of 9 to 15 (or even 17) cu. ft. capacity. A larger capacity is often desirable, and about 20 years ago a four-wheeled machine carrying two of the ordinary scrapers was tried, but without satisfactory results. More recently a four-wheeled machine with a scraper of 1 cu. yd. capacity has been introduced, and this has been used with success in a number of construction works.

A steel frame is carried by two axles, having 30-in. front wheels and 48-in. rear wheels, and its forward end is arched so as to clear the wheels and allow the machine to make a very short turn. The steel scraper bucket is 46 ins. long, 45 ins. wide and 25 ins. deep, with a nominal capacity of 1 yd., but heavier loads have been excavated and hauled. The rear end of the bucket is suspended by short chains attached to the sills of the frame and to the bottom corners of the bucket. The front end of the bucket has a bail pivoted to the bottom corners, with chains passing over a shaft carried above the frame. This shaft is fitted with sprocket wheels driven by chains from the axle, a clutch enabling the shaft to be thrown in or out of gear. The driver sits at the rear, where he has a good view of the work. He handles the levers for controlling the movements of the bucket, in loading, dumping and spreading, and no extra men are required at the scraper in loading or dumping.

In loading, the forward end of the bucket is lowered and inclined forward, so that its cutting edge touches the ground. An end gate at the rear retains the material. When loaded, the front end is raised by the chains on the shaft so as to bring the bucket to a practically level position, when it has plenty of clearance for hauling. An automatic trip releases the clutch when the scraper is in this position, thus preventing accidental overwinding of the chains and dumping of the load. For dumping, the chains are wound up still farther so as to raise the front end and tilt the bucket backwards, falling clear of the end gate. The load may be dumped in a heap at one spot, or spread in a thin layer, according to the inclination given to the bucket. The operations are shown in Figs. 1 and 2, which show the loading and dumping respectively. The front and rear wheels do not track. This feature (in combination with wide tires and the weight of the machine) reduces the tendency to wear ruts, and is efficient in rolling and compacting the material, as in embankment work.

From two to four horses (or mules) haul the machine, according to the character of the work, but in loading an extra four-horse snap team is generally used. Hard ground must be plowed to enable the horses to do efficient work in loading, but this is not necessary when traction engines are used, as has been done in several cases. Engines of 12 to 16 HP. have been used for loading, and sometimes they are used also for hauling, the engine taking a train of two to six scrapers.

The cost of loading is estimated to average 4 cts. per cu. yd. in ordinary material. The cost of hauling varies with the grade and condition of road, etc., and ranges from ½-ct. to 1 ct. per cu. yd. for each 100 ft. of haul up to 1,000 ft. Working in a hard and heavy brick clay at St. Louis, a 16-HP. traction engine was used for loading, and three horses to each scraper for hauling. The loading averaged 1¼ minutes, or 48 loads per hour, with an average of 29 cu. ft. to each load. The machines have been used on railway and reservoir embankments in California; in the latter case the borrow pits were small and scattered, and the haul varied from 200 ft. to 1,500 ft. Their work on the South Branch Canal of the Klamath irrigation project in Oregon (U. S. Reclamation Service) is reported as follows by the contractors, Wells Brothers, of St. Louis.

> From original surface of ground to top of dyke averaged about 14 ft. The canal was built in the embankment and the bottom of the finished canal was 8 ft. above the original surface of the ground. The entire embankment went up in 6-in. lifts, each lift being sprinkled. The specifications called for each lift being rolled with a grooved roller weighing 1 ton per ft. of tread, but the Government engineers and inspectors ordered us to take the roller off, as the wheel-scrapers answered to better advantage owing to the front wheels having a narrower tread than the rear ones, and the wheels packing the material better than the roller would have done. The wheels would pack it in low places where the roller would have run over without touching.
>
> The average haul was 400 ft. from borrow pit to dyke. After 18 ins. were removed from the borrow pit, hardpan was encountered requiring eight and ten head to plow. This latter material was handled to the depth of the pit, which was 5 ft. This material could not have been handled at all with grader and wagons, nor with ordinary wheeled-scrapers with profit. The 170,000 cu. yds. handled cost 14 cts. per yd., including the cost of moving to and from the work, which amounted to about $2,000.

These large-wheeled scrapers have been used in street and road work, for levees and ditches, railway embankments, canal excavation, and miscellaneous light and heavy grading and filling. On one job 50,000 cu. yds of loamy soil were removed from ridges and deposited in a pond of water, with an average haul of 200 ft. The cost of this work is said to have been only 10 cts. per cu. yd. In New York, the machines have been used for removing snow, loading it from the winrows formed by plows.

These four-wheeled scrapers are built by the Maney Mfg. Co., of East St. Louis, Ill. For particulars of their construction and use, we are indebted to the Barron & Cole Co., of New York, dealers in contractors' supplies and equipment.

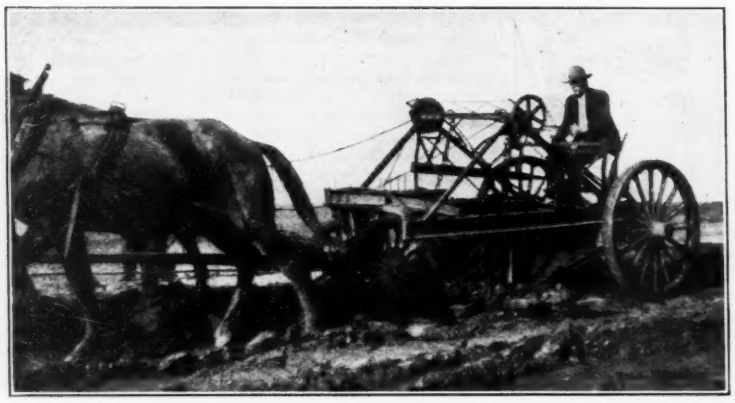


Fig. 1. Loading.

Fig. 2. Dumping.

FOUR-WHEELED SCRAPER WITH BUCKET OF 1 CU. YD. CAPACITY.

Maney Mfg. Co., East St. Louis, Ill. Barron & Cole Co., New York, N. Y.

Reclamation and Army Engineers.*

A tentative suggestion comes from Washington to the effect that the President plans to detail an Army engineer as Director of the Reclamation Service in place of Mr. F. H. Newell. Whether this is determined or is merely a toy balloon sent up to attract sharp-shooters, is uncertain. Unfortunately there is reason to suspect that the project is serious. When Mr. R. A. Ballinger was made Secretary of the Interior it was widely published as coming from him that he would "get" the Reclamation Service, and it has been an open secret that there has not been that harmony between the Secretary and the officers of the Service that under the previous Administration did so much to promote the efficiency of that great Bureau.

Civil engineers have been especially proud of the record made by Mr. Newell and his associates. They have demonstrated that it is possible under conditions of Government service to build great engineering works honestly and efficiently.

The Army engineers, frankly, have been jealous of any movement to place construction of public works in the hands of civilians. The officers of the Corps of Engineers are excellent routine administrators, as would be expected from their training. They are men of high character, and with their system of retiring allowances, which are denied to civilian employees, it is possible to keep them in the service. Fewer men resign to enter private practice than in other branches.

All this may be frankly admitted without conceding that they should be placed in charge of all engineering work. In practice they have not proved to be especially brilliant engineers, and the bulk of their work is done by civil engineers employed by them, but denied high rank and pay. The original reason for giving them charge of public works, that they might be profitably employed in times of peace acquiring experience, broke down when during the Spanish War so few were transferred to active service. The Army has its own work and its men should be kept at that. There is no more reason why Army engineers should build irrigation canals than for them to have charge of the post-offices.

A TEST OF A REINFORCED-CONCRETE FLOOR was made recently under very unusual conditions, including a fire test with the floor under load, the fire test apparently being required under the city's building ordinances. The structure was a 10-story office building, with floor panels 22 × 20 ft. c. to c. of columns. The floors were designed for a working load of 100 lbs. per sq. ft., and were required to stand a test load of 200 lbs. per sq. ft. with a deflection not exceeding ¾-in. According to the information furnished to us, the deflection with this latter load on a test panel of the floor was only ⅛-in. The building inspector then had a fire test made of the loaded panel (without the approval of the designer), and with a hot fire beneath the deflection increased to 1⅛ ins. Water from a fire hose was then thrown upon the bottom of the heated slab, and the recovery was ⅞-in., leaving ¼-in. deflection. A small amount of concrete spalled off under the action of the stream of water. The building inspector considered the result unsatisfactory in leaving ¼-in. deflection, and the approval of the structure on behalf of the city is now in dispute. It is pointed out that the heated bars in the lower part of the slab may have taken a slight permanent set as the effect of the sudden cooling. While many fire tests on concrete slabs have been made in special test chambers it is very unusual (to say the least) to require such a test in a completed building.

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The great extent to which engineers are being employed by contractors, both in responsible and subordinate positions, is a marked feature of present day construction work that must impress itself rather forcibly upon anyone who is in touch with work of this kind. The time is not so very far past when a contractor would have regarded with contempt any suggestion to employ young engineers (especially college-trained engineers) upon his staff. An engineer of long experience might be all right to make calculations and drawings, or even estimates, and to set stakes or give lines, but he was considered quite incompetent to direct work, to handle men, or to comprehend the "dollars and cents" factor of the contracting business. The actual work, it was thought, must be in charge of a "practical" man, usually a foreman or a superintendent graduated from among the foremen. We are not slighting these latter men in any way; they were likely to be men of ability, readiness and courage, but they necessarily relied upon intuition and rule-of-thumb rather than upon scientific deduction. In financial matters also, they were extremely likely to consider cheapness rather than economy, and to aim at reducing the current expenses rather than the ultimate cost of the work. But it is apparent that the view of the contractor is changing, partly, perhaps, because he too is likely to be more or less of an engineer.

In a recent visit to some important tunneling work, many of the sections were found to have been placed by the contractor in entire charge of young engineers, most of whom had had some railway or other engineering experience. The general impression was that they found contracting work more to their liking, as giving them a wider range of experience and a greater field for the exercise of ingenuity, and also as imposing upon them more direct and individual responsibility for the outcome of the work. Each man was in responsible charge of his section, subject of course to the general instructions from and the occasional visits of the contractor himself. These visits, however, were comparatively rare, but not because the contractor was at all neglectful of his work. The simple reason was that he felt entire confidence in his men and in their ability to handle the work, not only with efficiency but with economy, and with a clear idea as to the contractor's interests and the financial profits. And these, be it noted, were not men of long years of experience, but young men (bright, active, and sharp, of course) with probably an average of three to five years' experience in rather varied lines of engineering. In the meantime, the contractor was free to devote his time to the broader field of looking up new contracts and planning new work.

The contractor's engineers (or superintendents) had entire charge of the men and machinery equipment, planned the methods of attack for the tunnel headings, the arrangement of machinery and appliances for mixing and handling concrete, the design of concreting forms (with a view to minimum loss of material), and the general task of keeping the various processes and stages of work in harmonious progression. On such work efficiency is not the only requirement; equally necessary is the requirement of economy, doing work as good as necessary (but not unnecessarily good) at the lowest cost, since the difference between cost and contract price represents the contractor's profit. Furthermore, the work as a whole must progress with a view to completion within the contract time (and with allowance for emergencies). If the engineer cannot make good in all these respects, he cannot hold his job. The case cited above is representative of many similar cases, and in these the work of the engineers forms an indisputable refutation of the old (but still living) fallacy that the engineer is not a "practical" man, but is simply a theorist, a surveyor, or an office man. The engineers in such positions as we have noted do everything that the so-called "practical" man (from the working ranks) could do, and do it equally well. In many cases, no doubt, they do it very much better (or to the better advantage of the contractor), owing to the advantages of their technical training.

In most cities, the monumenting of street corners, etc., for survey control has grown with the city, reaching out toward the suburbs as building and street extension required and interpolating in the city proper in unusual instances of lost marks, rebuilding or new paving. The result of this is that there is rarely any unity in the system of monumenting; the successive monuments along any street will only occasionally show a straight line, and the observed angles and measurements between any set of marks hardly ever agree with those recorded in the city plot-books.

To avoid these difficulties in the future, the city of New York, under its charter authorizing the greater city, had a triangulation made over the whole area of the city, according to approved methods of the U. S. Coast and Geodetic Survey, and under direction of one of the officers of that bureau. From this triangulation the intermediate areas are covered by traverses, from which all new monumenting is controlled. As a result there will be a unity about all future surveys of the city and an agreement between the survey marks as observed and as recorded which is impossible in the independent system of monumenting as practised in most cities.

It is evident that the value of the method adopted in New York increases directly as the accuracy of the intermediate traverses. It is, of course, desirable to have far-distant triangulation stations precisely located, but unless the accuracy of the traverses connecting the monuments themselves to these stations closely approximates the accuracy of the main triangulation, the minor points are but loosely determined. To procure such precision in the traverses would seem to be very costly and beyond the economical limit possible in most communities; but the article by Mr. E. H. Holden on "Primary Traverse Work of the Bronx Topographical Bureau," on another page of this issue, shows that with proper care and instruments the costs do not run any higher than ordinary careful transit work.

The high quality of Mr. Holden's methods is proved by the tabulations in his paper; an error of but 2" per angle is very close to primary triangulation requirements, and in most of the examples given the error is much smaller than this. In measuring, the one example given confirms the accuracy noted in the previous article on this subject by Mr. Holden in Engineering News. Not only is the error of two measurements with his Invar tape and line clinometers only 1 in 1,500,000, but the error between his measurement and the triangulated distance is but 1 in 87,000, an error so small as to ensure the location of any intermediate point, so that it will agree with the recorded plots and with any future survey made with equal precision. It has been the experience in the Bronx that this is procurable without excessive cost, as the tabulation in the article shows. Measurements by the most advanced method are cheaper than by the ordinary tape and plumb-bob method, and there certainly is nothing about the transit used or the method of reading angles to advance the cost over that with an ordinary transit.

Elsewhere in this issue we have reprinted a few figures on the operating costs and revenues of electric railways in New York State, as sent out by an association of such companies. It is interesting to note where the passenger's nickel goes to, accepting the reported figures at face value. Only a little over half a cent is spent in propelling a car, while a whole cent goes to control the car and collect the fares. Nearly one cent out of each fare is needed to keep up the cars and tracks; a little more than a cent is divided between taxes and interest; and about a cent more pays the general administration and similar expenses. Finally, then, something like half a cent, from each five, is available for profits. It is interesting to note that it cost the 74 scattered railways 5% more to operate than the largest ten companies and apparently with a corresponding reduction of comparable incomes, as the fares are the same in all cases.

Impending Changes in the Railway System of Great Britain: A Lesson for the United States.

"The old edifice of the English railway system is tottering to its fall and no one yet knows what will take its place." With this sentence Mr. W. M. Acworth, one of the best posted railway men in Great Britain, begins a paper which we publish on another page of this issue. As many of our readers are aware, the railway system of the United States is patterned closely after that of Great Britain. In the other great nations—Germany, France, Russia, Austria—government ownership of railways is the rule. Government ownership is the rule, too, in most of the minor countries; and in some countries which have not adopted Government ownership, the Government is actually closely concerned with railway operations through the grant of Government subsidies.

It is, broadly speaking, true, therefore, that Great Britain and the United States are the only two great nations of the world which have developed their railway systems by private enterprise alone and which have never in any degree adopted Government ownership of railways.

In both England and the United States, Government supervision of railway operation has been steadily increasing during the past quarter century. In England, however, competition in railway transportation has been maintained to a much greater extent than in the United States, and has been a chief reliance in securing for the public reasonable rates and efficient service. But there is now impending in England an era of consolidation and combination which promises to put an end to competition. It is this situation which leads Mr. Acworth to remark, in the paragraph from which we have quoted above: "In the near future we in England have to choose between state regulated monopoly in the railway business, or, as to me seems much more probable, state ownership and state operation."

To appreciate the importance of this state-

ment, it should be understood that Mr. Acworth is not only one of the best informed men in British railway circles, but is and always has been one of the strongest advocates of private railway management as opposed to government ownership or control.

The causes which have brought about this impending change in the British railway situation are fully set forth by Mr. Acworth. Briefly summarized, British railway managers are between the devil and the deep sea. On the one hand, their employees demand better wages and better conditions. In 1907, under the imminent prospect of a general railway strike covering the entire country, the railway managers were obliged to submit to arbitration questions relative to wages and hours of labor. On the other hand, there is strong complaint from freight shippers that the rates charged are too high, and strong pressure has been exerted through the British Board of Trade to bring about a reduction. And with this pressure to increase expenses and reduce earnings comes vigorous complaint from shareholders, who complain of scanty profits and low rates of dividend. Under the stress of this situation, competition in the railway business, so long maintained in England, broke down. Combinations were arranged between the different great railway companies which would have assembled all the lines into three or four non-competitive groups. It was hoped by this plan to reduce the heavy expenses caused by competition and thus enable the companies to better meet the demands of employees, shippers and stockholders. But when the sanction of the Government was sought for these combinations, great public protest was made and the desired consent was refused. Actual consolidation, therefore, could not be carried out; but a similar end could be and has been attained through private agreement. As Mr. Acworth tersely puts it, "Competition in fact is dead, and not all the king's horses nor all the king's men can bring it to life again." With competition ended, as a force in securing to the public good service at reasonable rates, it is undoubtedly true that England must choose between a long step forward in government control of railway operations and the adoption of state ownership and state operation.

Turning, now, to the situation in the United States, it is probably true that the general public at present regards government ownership of railways as a mere dream of the theorist. While such a policy might perhaps find considerable popular support, the business community undoubtedly would almost unanimously oppose it. It will be remembered that when this solution for the railway problem was proposed by Mr. Bryan in a public address a few years ago, there was a loud chorus of dissent.

But how long is the public likely to retain this position? We cannot safely shut our eyes to what is going on about us in other countries of the world. Within the past two years, Japan and Mexico have each undertaken the complete nationalization of their railway systems. Unquestionably the tendency is in this direction, the world over.

If Great Britain should take the step which Mr. Acworth declares to be probable, the United States would be left as the only country in the world having its railway system entirely under private management.

It is of interest to inquire as to the causes which have brought British railways into the unfortunate situation which Mr. Acworth describes.

It is a historical fact that when George Stephenson's great success with the locomotive inaugurated the railway era, the railway was regarded as chiefly a means of passenger transportation. The early railway promoters had no idea of competing with the canals in the carriage of coal and other low-class freights. Their ideas were directed solely toward the carriage of passengers at high speeds. The railway system of England, which was developed earlier than that of any other country, was particularly planned and has always been particularly operated, with passenger traffic as its main object. English railway men appear to have been slower than those of other countries to appreciate the fact that freight traffic rather than passenger traffic was the business paying greatest profits.

In the profitable handling of passenger traffic, moreover, English railways have always been hampered by the great handicap of the class system. The necessity of providing first, second and third-class accommodations in practically every passenger train was modified only a few years ago by the abolition of the second class on most English railways. The first-class and third-class, however, still continue in use everywhere. This system of classing passenger traffic, in conjunction with the use of the compartment system for passenger cars, makes it exceedingly difficult to load passenger trains to anything like their capacity. A large proportion of English passenger trains run with their seats not one-third filled. More important than this, in its effect on operating expenses, however, is the great number of station men which are necessary on account of the compartment system. While the wages of these men are very low according to our American standards, the number of employees is so great that the burden upon railway operating expenses is extremely heavy.

It will be admitted, of course, that the English system of handling passengers is so imbedded as one of the customs of the country that any radical change would be extremely difficult. Nevertheless, it is apparent that reduction of operating expenses is one of the first essentials to placing English railways on a proper financial basis, and the most direct means of reducing operating expenses is reduction in the number of trains and in the number of employees.

The second great handicap under which English railway companies labor is their enormous capitalization. Fortunately, this capitalization is in stock or debenture securities not subject to foreclosure. English railways, therefore, do not have to meet interest on mortgage bonds under the penalty of going into a receiver's hands. What does face them is general dissatisfaction on the part of their security-holders because of the low rates of dividend. Under present conditions, however, net earnings would have to be very largely increased to raise materially the rate of return to holders of railway securities, because the capitalization per mile is so heavy. The average capitalization of all the railways of Great Britain is about $270,000 per mile, which compares with about $75,000 per mile in the United States.

There are several reasons for the high capitalization of British railways. The first is the high class construction which has prevailed everywhere in England since the earliest days of the railway era. More important than this, however, is the very heavy expense which the railways were under to obtain terminal facilities in the cities which they entered. Ranking almost on a par with this are the very heavy parliamentary and legal expenses with which the railway companies were burdened in securing their franchises. Besides all these, the policy has always been in Great Britain to charge all expenditures on improvements to capital account. Where American railways have devoted a certain proportion of their earnings to betterment, British railways have conscientiously capitalized every expenditure which could not be classed as repair or maintenance. As a consequence, their capital has gone on rolling up like a huge snowball until the present stupendous figures have been attained.

While such a system of capitalizing expenditures on betterments may have a theoretical justification, it is inherently unsound. Take, for example, the very large fees paid to the experts who appeared before Parliament in obtaining the charters of some of the early railway lines. Because a company paid $50,000 to Robert Stephenson for his testimony before a Parliamentary committee 75 years ago, is it reasonable that the public should go on paying interest on that expenditure, not only for the 75 years that have elapsed since, but for untold centuries to come? Does not any such system of capitalization tend to break down by its own weight? Ought not a certain proportion of earnings to be annually set aside for the retirement of capital, or, what amounts to the same thing, for expenditure upon betterments instead of charging them to capital account?

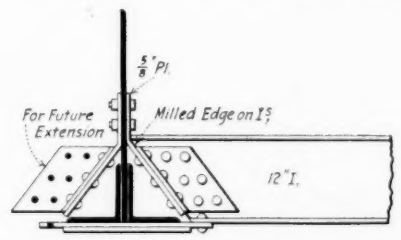
It has seemed to us important to call attention to this situation with respect to the railways of England because of the temptations now present to the railways of our country to repeat the same mistakes here that have been made there. American railway companies during the past ten years have been increasing their capitalization in a manner wholly unprecedented. Improvements of all sorts are paid for with a lavish hand so long as Wall Street will purchase stocks or bonds; and when these are unsalable, short-term notes are resorted to. Wherever the improvements to be made with this money will actually pay for themselves in the shape of reduced expense of operation or increased earnings, such added capitalization is, of course, justifiable; but if the secrets of all hearts were revealed, we fear that no small proportion of this added capital would be found invested in directions which promise small returns in the way of revenue and which will benefit the banking interests in control rather than the stockholders of the present or future.

We believe that in many respects the railway system of the United States under private management, and with the benefit of private initiative, is superior to the railway system of any other country. But if we are to continue to have these benefits—if the United States is not eventually to follow the example of all other nations by adopting government ownership for its railway system—then our railway magnates must realize their trusteeship in the largest sense. They must be willing to learn from the experience of other countries; they must be as ready to recognize the rights of the public and of their employees as they are to see the opportunities to make fortunes through the promotion of big deals and a vast outlay of money in extensions.

LETTERS TO THE EDITOR.

A Floorbeam Connection with Inclined Hanger-Plate.

Sir: I enclose herewith a sketch of a floorbeam connection as applied to railway bridges. This is a standard detail on at least one prominent road and I would like to find out from some structural engineers what advantages this has over other more simple designs.



This is one of the most important features in the design of a shallow floor bridge and as the conditions are usually very much alike it seems that the subject might be worthy of a little space to find the best design.

"Girder Bridge."

April 17, 1910.

Concerning Mooted Points in Reinforced-Concrete Design.

Sir: The letter of Mr. Alexis Saurbrey in your issue of April 28, criticizing my paper on "Some Mooted Questions in Reinforced-Concrete Design," is interesting, but Mr. Saurbrey is mistaken if he thinks I would undermine reinforced-concrete design. Highway bridge design has not been undermined by exposing and eliminating the weaknesses of details and design that are so common in the bridges built 10 or 20 years ago, and even now built where there is no disinterested engineering supervision. On the contrary this class of designing has been greatly improved and advanced. Sound engineering, that will stand the test of reason and simple formulas and design, is what I should like to see adopted.

I do not claim to have "discovered" the curved bend; but if it is so scarce in the literature of the subject that Mr. Saurbrey had to refer to a German book, just recently translated, for a sample, it was almost a discovery on Mr. Saurbrey's part to find an example in English.

The inconsistency that Mr. Saurbrey would find in my second and sixth points does not exist. What I criticize in the second point is bending up the rod and then ending it over the support without anchorage. What I commend under the sixth point is supplying the anchorage that is lacking in the other. When the lack of anchorage is pointed out to be the serious fault, it is not inconsistent to cite with approval a case where the anchorage is used.

It is gratifying to know that Mr. Saurbrey agrees with me when he says that in the "first stage" the stirrups are not stressed. Now what has a designer to do with the secondary or tertiary stages? Why should he consider a cracked beam any more than a distorted and partially failed steel structure? Consideration of a beam that has reached incipient or ultimate failure is valuable to determine the probable safe load; but it cannot be considered safe engineering to design a structure that will crack under its working load. Reinforced concrete beams and slabs can be made that will not crack under safe loads, in spite of the argument of the high-steel advocate and proprietor that the beams or slabs will crack anyway. This is not borne out by facts and calculated stresses in the steel are not very low either.

Mr. Saurbrey says, "Good engineers provide ample anchorage for bars." A little farther on he says of stirrups: "They do not therefore need full anchorage of 50 diameters, especially as they are embedded in concrete stressed in compression in a direction normal to their direction at the upper end." As I have already said, an iron vise firmly clamped on a few inches of a rod will not hold it for its full strength. How then could concrete, even if it were in compression, perform this office? And how can it be said that the concrete is in compression in the upper part of a beam near the support, where the stirrups are most needed? Even in a simple beam the compression amounts to little. In a continuous beam, the usual case, there is tension.

Instead of putting the rope around a post and pulling at right angles to the post, as Mr. Saurbrey suggests, put it around the rope of a rope drive and try to stop the latter by pulling at right angles to it. This better represents a U-stirrup.

There is scarcely any need of a dissertation on what is shear in a beam, or whether it is a force or a sum. We all know what is meant by the shear in any vertical section of a beam. We know that the web of a plate girder is designed to take this shear at so much per square inch; but when it comes to a concrete girder the shear is etherealized by some designers and writers, so that it can reach the support in some such way as an electric current would pass. Cut a section vertically through a beam between two vertical stirrups. What takes the shear in that section? Let it be a force or a sum, the shear is a reality in any event. If it is taken by the concrete, why not say so and drop all Howe truss arguments? If the shear or any part of it is taken by the stirrup, what about its jumping from stirrup to stirrup? The concrete cannot take it without tensile stresses. The tension rod can only take it by bending, which entails shear in this same tension rod. How could a shear bar normal to a tension bar be stressed in tension as the vertical of a Howe truss unless the tension bar is in bending by the concentrated loads of the shear bars. The Howe truss has a diagonal compression member centering at the intersection of the vertical and bottom chord tension members. The reinforced concrete beam has nothing of this sort.

Mr. Saurbrey in speaking of my criticism of the T-beam says that it is not verified by his experience. Has he perception to look into a beam and read its internal stresses. Of what definite value can experience be in this respect, unless it is experience with actual failures? There is a wide gap between complete safety and collapse. A structure may be on the verge of failure and remain so for years, and yet it may show absolutely no visible sign of its dangerous condition. My experience with T-beams has taught me that cracks in them are very, very common, and these cracks are not the "minute cracks discovered in recent years."

Speaking further of the T-beam Mr. Saurbrey cites a beam with the rods anchored in the next span as a proper example. This is one feature of construction that I have always most strongly commended. I mentioned it under the sixth point. But this is not the way a T-beam is commonly made. There are numberless examples of T-beams that have straight rods along the bottom or bent-up rods reaching only to the support or even short of the support. The stem of the T must give the increments of stress to the tension rods, and this stem is too narrow. When the bar is curved up and run into the next span, the concrete T simply rests on the rod as a saddle. Increments to stress in rod or grip of the rod in the stem of the T need not be considered.

My paper was not written to give specific formulas, but was a cry for simplified and sensible formulas. If Mr. Saurbrey wishes to know the formulas which I would use, and which he says are conspicuous by their absence, and to know how I would design an arch without an elastic theory, he can find all of this in my book "Concrete."

Mr. Saurbrey says, "A fixed arch, calculated as a two-hinged arch, but with solid connection to the abutments, would undoubtedly crack at once." Here is a most astounding assertion. Given two arches spanning the same opening and carrying the same load. One is much stronger than the other, being thicker in the arch ring and more heavily reinforced. Both are built in the same manner. By Mr. Saurbrey's statement the stronger one will crack, while by inference the weaker one will retain its integrity; and why? For no other reason under the sun than the process of reasoning in the mind of the designers. The effect of mind over matter may be real in some lines; it does not count for much in a case of this sort. It would be a good thing in some cases, very often in reinforced concrete as it is commonly designed, if physical materials would act just as a designer intended them to act. A good many wrecks would never have taken place if this were true. But it is not true, and it behooves engineers to bear this in mind. It is to combat just such erroneous notions as this that my paper was written. Because some high authority says that concrete and steel combined in certain ways will act just so, and this in the face of tests and wrecks that give the lie to these assertions, designers go on using these wreck-breeding methods and fall back on their "authorities" for justification, or else blame the wreck on some dead workmen.

Tell a railroad engineer that his bridges are safe if every train that rattles over them opens up new cracks—"recently discovered cracks"—he will laugh in your face. This is not engineering, it is a defi to Providence and a bid to disaster.

Hooped columns are strong, there is no question about it. And the strength of a hooped column with all of the parts properly balanced may be just what the discoverer of the hooped columns found it to be, though his formula is irrational and misleading. But take that formula apart from his work, divorce it from certain fixed proportions of parts to maintain the "balance," and error is perpetrated. Space the hoops a foot apart and the hooped column formula has absolutely no meaning. It is as rational to apply the hooped column formula with hoops widely spaced as it is to say that, of two buckets having equal dimensions, one having a wire bottom will hold as much water as the other with a solid bottom.

Mr. Saurbrey's last assertion is the most astonishing of all. He says, "It is unnecessary to go into details regarding the column reinforced with longitudinal rods only, as no one at any time has claimed any carrying capacity for such columns in excess of the strength of the plain concrete, or even less." Has Mr. Saurbrey been dwelling in Utopia? It is hard to find a book on concrete that does not recommend exactly what he says "no one at any time has claimed," namely, the addition of large carrying capacity because of longitudinal rods. Prof. A. N. Talbot, in Bulletin No. 10, of the University of Illinois Engineering Experiment Station, after recording a number of tests which generally show greater strength in plain concrete than in columns with longitudinal rods gives a formula which adds from 12 to 25% over the strength of the concrete for each per cent. of longitudinal steel. But the devil is beaten around the stump by saying that "By the method of analysis used, the average maximum stress in the concrete for the reinforced columns tested is found to be 15% less than the average for the plain columns."

Designers are quite selective. They will choose the coefficient of elasticity that best suits the nature of the competition. Also the concrete which they intend to make is not like that made by university students but will stand even more than those students' plain concrete. In Maurer & Turneaure's book, page 188, they say, "The use of each 1% of steel adds 14% to the strength of a column." Actual designs of viaducts and buildings with longitudinal rods in the columns are too numerous to mention. And these rods are not thrown in as a bonus. They are given all of the value that the books allow. A failure in Madrid, one in Philadelphia, one in California, one in Rochester, tell the tale of longitudinal rods in columns more vividly than I could recite it.

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., May 3, 1910.

Comments on Prof. Swain's Article on Floods and Forests.

Sir: The underlying motive of Prof. Geo. F. Swain's argument in the Engineering News of April 14 is to connect the forest problem with the navigability of rivers and hence the questions involved are of considerable national importance. The position of the "foresters," of which body Prof. Swain is a prominent representative, may be briefly stated as follows, to wit:

First: The forests, especially on the mountain slopes about the headwaters of the streams, tend to equalize the discharge of water from rains and melted snow, restraining the floods on navigable rivers and increasing their low-water discharge from reserves of ground storage.*

*To amount to anything for the benefit of open river navigation, the volume of such reserve water must be very great.

Against this proposition some of the engineers engaged on river improvements contend that observations of river-gage records and calculations of stream discharge lend but little, if indeed any, support to the theories of the foresters. Among other things it is contended that the percentage of rainfall discharged by the rivers during the winter or flood months, indicates, at least for most of the Ohio valley, but a limited contribution to ground storage during that time and that this storage capacity is usually taxed to its utmost limit before the close of winter and hence its restraining influence would seldom be of any importance. It must be the case that the line of permanently saturated soil and rock on great areas is much nearer the surface than it is commonly thought to be. This is undoubtedly the case where short-lived "wet weather" springs abound, the most prolific of which cease to flow in a few hours after the storms have passed.

Second: On the part of the foresters it is claimed that the destruction of forests leads to such soil waste or erosion about the headwaters as to result in the silting up of the beds of our navigable streams and thus to interfere with traffic upon them.

Against this it is replied that on the Ohio, at least, by reason of the greatly diminished number of snags and the effect of training works constructed by the Government at occasional points, there is much less silting than formerly, and that in consequence the navigable depth is somewhat better and very much safer. With the reduction in numbers of snags and tree trunks which in old times formed the nucleus of sand bars, the force of the flood currents tends to create and maintain a more uniform cross-section, with less undermining of the banks and consequently greater stability of shore bars.

Speaking of the San Francisco River, in Brazil, the late W. Milnor Roberts said the permanent shore and other bars were a distinct advantage to the navigation of the stream by contracting the discharge in wide places and thus, with a given volume of water, increasing the navigable depth. The present writer, whose experience on Western rivers dates from 1866, and who is very familiar with the stories of pilots extending back to 1837, takes this occasion to emphasize the statement that the Ohio is greatly improved over its old-time conditions in every respect. Regarding the Ohio's low-water discharge, certain U. S. Indian Commissioners, in 1785, reported such tributaries as the Little Miami (1,800 sq. mi. drainage area, near where Cincinnati has since grown up) so low that there was no water visible flowing from it into the Ohio.* The figures of measured discharge, reported by Col. Charles Ellet, at Wheeling, and Major Sanders, at Pittsburg, in 1838, were as low as the discharge for 1908. The year 1854 is thought to have been about the same as 1838 and 1908, but the actual minimum discharge was not obtained in 1854. Or, again with Judge Hugh Brackenridge's (afterwards Chief Justice of Pennsylvania) account, published in 1786 in the Pittsburg "Gazette," of a flood in the Allegheny scouring away the river bank near Fort Pitt, totally destroying a long row of houses with their gardens, it is difficult to believe man's operations in the past century have resulted in detriment to the river.

Prof. Swain admits, and it should be generally understood, that grave doubts are entertained by some of our national legislators as to the right of Congress to authorize expenditures for the purchase and reforesting of land unless it can be clearly shown that such expenditures will result in a benefit to the public and are necessary to the improvement of inland navigation.

It is, however, only quite recently that the foresters have proposed to take the navigable rivers under their wings. Formerly it was the matter of diminishing timber supply and advancing prices to which they particularly directed the attention of the country, and to this good work no one ever raised a voice in opposition. When, however, they encountered the constitutional difficulty above referred to they at once proceeded to annex river improvement plans to their field of enterprise.

Some of the first claims of the foresters against the operation of the river engineers were ridiculous in the extreme. Thus, for instance, that with forest conservation, aided by occasional reservoirs over the basin of the Ohio, locks and dams would be useless, that perennial depths of six or more feet could be maintained from near the heads of the principal tributaries, which would afford unobstructed navigation the year round. It was also claimed that the floods could be kept below the danger line and that the income from water powers would compensate for the necessary expenditure.

Propositions, looking to these ends, were put forward in a most alluring manner in magazines and newspapers, and through boards of trade and lecture bureaus, while university professors stepped into the field to work for the common cause. There is no doubt about it, it was a common cause, for the people everywhere agreed with the editors, professors and lecturers. Even to-day if the question were to be decided by numbers, the foresters would win by a tremendous majority, and it is

*The commissioners reported that their flatboats were frequently aground on the shoals, which were as bad below Wheeling as above that point. See "Olden Time," Robert Clarke & Co., Cincinnati, Ohio, 1876.

rather odd they have not before this secured their desired legislation. There must be, it appears, some things which almost every one thinks should be done, which are not done because of the restraining advice of but a few individuals. It is probably the case that while the mass of the people are with the forestry leaders in sentiment they are not overly excited and are ready and willing to listen to representations of the "corporal's guard" in opposition to the foresters. It was so in 1885 when the present writer was actually invited by the American Forestry Congress to appear before that body and address it, the invitation being accompanied by the friendly advice that the guest would be appearing before an audience unanimously hostile to his views. A personal appearance was not possible but the Congress very generously published his paper without an axe mark in its proceedings.

To-day, however, the number of those in so-called "opposition" to the claims of the foresters regarding river improvements is larger and increasing in numbers and the congressional committees are willing to hear them. Not for one moment should the river engineers and their little band of friends be considered as hostile to the proposed expenditure of $5,000,000 for Appalachian and White mountain lands for the purpose of converting them into natural forests, but they do not believe in attempting to justify such an expenditure on the ground that it will better the navigable conditions of the rivers, or in any way reduce the expenditures necessary to complete the projects now under way for the improvement of inland navigation.

Too much biased or, rather, extravagant opinion, unaccompanied by the data on which it is based, creeps into the discussions of the forests and floods problems as presented by such writers as Prof. Swain, and really does his side of the question more harm than good. It has been pointed out frequently by meteorologists how common it is for erring humanity, trusting to individual recollections, to assume that the climate is changing, especially as to snowfall, and then come ill-founded deductions and theories based upon them, all firmly believed; the more so because they are rarely contradicted, but nevertheless wrong. Thus, for instance, Prof. Swain goes back as far as the 1879 report of the Chief of Engineers, U. S. A., to quote Major Charles O. Allen, as follows:

> The weight of evidence collected by various writers upon the subject of rainfall seems to indicate that reforesting of extensive areas of country is followed by a more equable distribution of the rainfall throughout the year.

More personally painful is the statement that Prof. Swain lays bare regarding the weakness and ignorance of the present writer when he wrote, in the same 1879 report, as follows:

> The clearing of forest lands, I believe, is followed by greater fluctuations in our rivers. I think the storm waters undoubtedly reach the streams more rapidly now than formerly.

This exposure makes the present writer feel more disposed to forgive the weakness of others who lingered longer outside the "true faith" than he did. The present writer began to be converted in 1883 and was nearly turned around to the side of recorded facts, especially those of long-continued European river observations, when he was called to appear before the American Forestry Congress in 1885.

Major Charles W. Raymond, writing in the Chief of Engineers' report for 1891, is also quoted by Prof. Swain as follows:

> The destruction of forests from the mountain crests and slopes of a water shed is undoubtedly the principal cause of the increase of the average magnitude of floods. The evidence collected during the past twenty-five years, establishing this conclusion, is well-nigh overwhelming, and it is verified by repeated observations not only in the mountains of Europe but also in our own land. . . . Col Torrelli affirms as the result of careful observations that four-fifths of the precipitation in forests is absorbed by the soil or detained by the surface of the ground to be gradually given up in springs and gentle rills and only one-fifth of the precipitation is delivered to the rivers rapidly enough to create floods. Upon the same slopes and surfaces denuded of their forests the proportions are reversed.

It is to be noted that this is a difference of four to one in favor of the forests. There are so very many negative results shown in the studies of river records as to leave no standing whatever for such wild claims as those made by Col. Torrelli.

Prof. Swain should not speak of "careful observations," when quoting others, without looking them up, especially in view of the fact that in other parts of his paper he disclaims some of the extravagant claims made for forests in restraining floods.

On the subject of erosion, also, Prof. Swain can be criticized. In the place where he is trying to corner Prof. Willis L. Moore, as if to illustrate, he says:

> The immediate effect of deforestation on floods and in the deposition of sediment will clearly be felt first in the upper reaches of the streams, on the Ohio River, for instance, at Pittsburg and points above.

The case probably looked good on the map, but the professor could scarcely have made a greater mistake than in choosing the upper Ohio. In many places in western Pennsylvania and West Virginia very steep hillsides may be seen which have been plowed and cultivated for decades and still they are planted in wheat and corn without the least attempt to fertilize them and with little done with ditches to carry off surface water. When left fallow the bared ground is productive of grass quite sufficient to prevent gullying. There are regions of steep slopes in the glacial drift areas of the upper Allegheny, formerly heavily covered with pine trees, now bare excepting for grass, while the streams issuing from such comparatively bared regions have the largest low-water discharge per unit of area of any streams in Pennsylvania, unless exception be made of the limestone district of the Cumberland Valley west of Harrisburg. The Monongahela River is much clearer at medium flood and low stages now than in early periods, for it was formerly muddy the year round and was called, in some Indian dialect, "The Caving Bank," or the "Muddy River," "Monongahela" meaning muddy or caving bank. Its extreme clarity at low-water periods of later years, it is proper to say, is due to acids reaching it from coal mines and galvanizing establishments.

It is, however, time that a treaty of peace be made between the contending factions of the forestry and flood problem. The present writer believes that the river engineers will join with the foresters any time for the salvation of our forests. They may want to stand on the proposition, however, that the irregularities of the rivers are due to their habit of following the irregularities of precipitation, irrespective of the nature of the cover on the ground. The present writer, who claims to be a disciple of the river engineers, would like to present as an article for the treaty of peace, that there is an analogy between the annual discharge of the upper Ohio and the variation of levels of the great lakes, for the purpose of showing that whatever it is which produces extremes of drought or high water in the Ohio, has its seat of operation in the Gulf of Mexico and the Pacific Ocean; that the forested areas of the Central United States are creations of those operations, and that cutting away the forests has in no wise interfered with them, or reduced or increased the volume of the Ohio returned annually to the ocean.

It is to be feared, however, that no lasting peace can be made until the meteorologists and the hydrologists have worked up all their available data—they are the court of last resort—and deal only with facts and figures, as indeed the engineers have tried to do, but have not always been well treated by the popular tribunals.

Very truly yours,

Thomas P. Roberts.

U. S. Engineer's Office, Pittsburg, Pa., May 3, 1910.

[We wish to direct particular attention to the last paragraph of this interesting letter, and to urge, as we have done before, that a large part of the confusion which has appeared in the discussions of both sides of the subject has been due (1) to the notable lack of scientific data covering all phases of the forests, stream flow and floods controversy and (2) to a general failure to use, or use rightly, the meager data available.—Ed.]

The Inventor of the Direct-Acting Explosion Pump.

Sir: I should like to examine critically the letter of Mr. H. A. Humphrey, in your issue of April 7, in which he comments on my claim of being the real inventor of the direct-acting explosion pump, contained in a letter in your issue of Feb. 10.

Mr. Humphrey, in his letter, says in effect: (1) That neither of us is the inventor; (2) that we have approached the subject on very different lines; (3) that he regards my pump as of little value; (4) that my pump is inefficient because it employs a water-piston of small mass; (5) that the great size of his pumps render them significant; (6) that the pumps designed by him differ entirely from the Smyth pump.

These points I wish to discuss in their order. In what follows the italics in each case are mine.

(1) In Mr. Humphrey's statement that

> neither * * * can claim to be the inventor of the direct-acting explosion pump seeing that it dates back to 1868

there is no claim that he anticipated my invention or that his designs do not come within my patents. The statement would have been more convincing had he specified the person, thing, happening or document of 1868.

(2) He states that "we have approached the subject on very different lines." A complete answer to this is given by stating a Principle or Law of Operation on which both his and my devices are based. *It consists in allowing the energy of expansion to act upon a liquid so as to impart momentum thereto and thus to produce a diminution of pressure behind it, thereby entraining fresh liquid and a fresh charge, and utilizing the return of the liquid to compress the fresh charge.* This is a perfect statement of the principle, and it perfectly and equally applies to both devices.

(3) Mr. Humphrey states also that he has regarded as unpractical and of little value any scheme for raising water by explosions in which the products of combustion become mixed with the water raised.

This is obviously inconsistent with the actual construction of the machines designed by Mr. Humphrey. If his object had been the reverse of that indicated, had he desired, in fact, to transfer the objectionable elements of the spent gas to the water raised, he could hardly have hit upon a better plan than that of the multitude of small suction-valves. The introduction of the suction-water in converging, hollow, impinging, spray-producing streams, dashing into and among the expanded gases constitute an effective gas-washer or gas purifier. The fact that under these favorable circumstances no appreciable contamination occurs, bears out my oft-repeated experience that, even in water repeatedly pumped, no contamination can be detected by taste or smell.

(4) I note this in Mr. Humphrey's letter:

> I have also been careful to avoid the "violent" surging of the water piston which Mr. Smyth seems to regard as a "most highly desirable condition" and which results from allowing the explosion to act upon a relatively small water piston. I purposely choose a large mass of water so that the velocities are not too high.

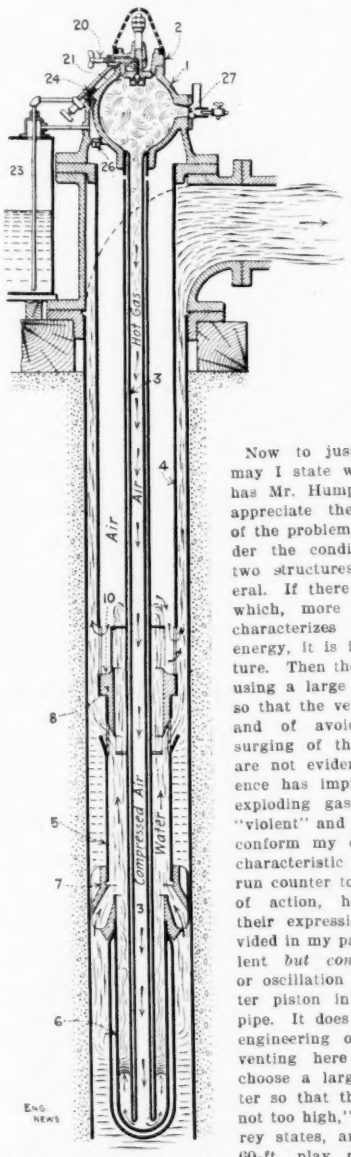


Fig. 1. The Smyth Direct-Acting Explosion Pump.

(Reproduced from U. S. Patent Specification 936,677.)

Now to just that extent, may I state without offense, has Mr. Humphrey failed to appreciate the requirements of the problem, not alone under the conditions of these two structures, but in general. If there is one quality which, more than another, characterizes explosive heat energy, it is its fugitive nature. Then the advantages of using a large mass of water so that the velocities are low and of avoiding "violent" surging of the water piston are not evident. My experience has impressed me that exploding gas is by nature "violent" and it has led me to conform my designs to that characteristic rather than to run counter to natural modes of action, however violent their expression. So I provided in my patents for a violent *but controlled* surging or oscillation of a small water piston in a short drive pipe. It does not seem good engineering or scientific inventing here to "purposely choose a large mass of water so that the velocities are not too high," as Mr. Humphrey states, and to employ a 60-ft. play pipe.

If I assume, as I may, that the elaborate articles in London "Engineering" of Oct. 5, 1909, and Feb. 11, 1910, received Mr. Humphrey's careful scrutiny and that they accurately reflect his views, then a remarkable and significant "about-face" on this very point is shown. His attitude of mind is irreconcilable with his statements in your issue of April 7. For instance, the "Engineering" article of Oct. 5, 1909, states:

> This (the ignition of the charge—W. H. S.) sets in motion the water in the long U-leg *which forms an essential component of the pump.*

Now this is in full accord with his statements to your readers, but it is at variance with the later article in London "Engineering." This article concludes with the statement that it is

> for the purpose of showing the advantage of a *short* as

compared with a long play pipe * * * and this has been the primary object of this article.

The article also states:

* * * improvements in the suction-valves are the only elements lacking, to the *cutting down of the play-pipe to a few feet* only, and to the *adoption of much higher velocities* of flow than were made use of in the trials referred to in the paper. The design of suction-valves to pass very large volumes of water, and at the same time of such a type as not to interfere with the free oscillation of the water-column in the play-pipe, is a problem of some difficulty; but we have no doubt that it will not prove insuperable to Mr. Humphrey's ingenuity, and that even better results than any yet recorded at Dudley Port will, before long, be obtained.

A detailed examination into the theory of the pump shows that there is *not* necessarily any connection between the equivalent head, against which the pump works, and the length of the play-pipe. If, for instance, (as in the Smyth patent of Oct. 12, 1909—W. H. S.) pumping is effected against an artificial head due to the pressure of the air contained in an air vessel, the length of play-pipe may be actually shorter than the equivalent hydrostatic head. * * * Actually the play-pipe between the air vessel and the combustion-chamber was long, but, so far as the mathematical principles are concerned, *there is no reason why it should not have been some 10 ft., or even less*, in which case it would have been a mere fraction of the effective head. In fact, were perfect inlet-valves available, *the shorter the play-pipe the greater would be the output* of the pump for a given maximum velocity of flow, and the higher the over-all efficiency of the apparatus. * * * *The advantage of the short pipe is, it will be seen, very considerable.* * * * The long cycle which is associated with the long pipe affords ample time for the inlet-valves to open and close. There is thus less wire-drawing of the water, and less waste in eddies around these valves. In practice, therefore, it will be necessary to effect a compromise between the considerations imposed by the inefficiency of the suction-valves, which, taken per se, is reduced by the use of a long play-pipe, and the conflicting claims based on the essential principles of the pump, which, on the other hand, *make a reduction in the length of this pipe advisable.*

It thus appears that the device of the Smyth patents had, by the simple expedient of a short "drive-pipe" and the absence of suction-valves, already cut the Gordian knot of the conflicting conditions in which Mr. Humphrey is still entangled with his long "play-pipe" and "inefficiency of suction-valves." This also strongly suggests that the pump designed by Mr. Humphrey can attain its best efficiency only as it still more accurately follows my patented disclosure.

(5) In the letter of April 7, I see Mr. Humphrey's statement that he has made units of up to 6,000,000 gals. daily capacity. Now beside these units, any of the dozen or more direct-acting explosion pumps which I have built and operated would cast only a small shadow, but the relative significance of the mechanical structures must not be gaged by size alone. Questions of efficiency enter into any comparison of the relative importance of the English and the Californian machines; the efficiency of the former is due to its size, while that of the latter is due to its nearer approach to correct principles. I will content myself with stating that, in some instances, my results exceed those of Prof. Unwin's reported tests. (See Engineering News, Dec. 2, 1909.) How much so I would hardly dare say unless supported by evidence as authoritative as the English tests. It is my belief also, based on my experience, that radical changes in design, other than those spoken of in London "Engineering" Feb. 11, will be necessary to bring the Dudley Port machines up to proper efficiency.

(6) Says the letter in your issue of April 7:

The Humphrey pump * * * differs so entirely from that described in Mr. Smyth's specification that, had it also been illustrated, your readers would have found it difficult to see any practical points of resemblance.

I am glad to adopt the suggestion and submit a drawing of my device (see Fig. 1) for comparison with Mr. Humphrey's as shown in your issue of Dec. 2, 1909. I append a brief description and for full details refer to my patent, No. 936,677, of Oct. 12, 1909. For convenient comparison with the patent specifications I have adhered to the nomenclature and numbering there used.

A pipe 3, of small diameter, extends down, from the lower end of the explosion chamber 1, into the well (in this design). Outside of pipe 3 is pipe 4, of larger diameter, forming an air chamber. Below pipe 4 is pipe 5 (which I denote as a "drive pipe"), and below this is pipe 6 closed at its lower end and forming, with pipe 5, an expansion space for the hot gases. Between pipes 4 and 5 is an annular fitting, concentric to both pipes, which I term a splitting nozzle 8. Openings are provided at the upper end of pipe 5 and at the lower end of pipe 4 on each side of the splitting nozzle. A well casing encloses all these pipes and serves as a supply and discharge pipe, with a discharge head in this particular case supporting the explosion chamber and supply mechanism.

The upper works are designed so that fuel shall enter the explosion space only when the air-inlet valve 2 is closed and so that the supply shall commence with the closing of this valve and shall continue until the explosion pressure checks it by the ball valve shown. The fuel passage in the valve 2 may be cut off from the vaporizing chamber 21 by a needle valve also. This chamber has a pipe leading to an airtight fuel tank 23. The chamber is also connected to the upper air chamber of the pump by the atomizing plug 24 and the check valve 26. The fuel tank is also connected to the air chamber by a pipe. Thus it is seen that the fuel-tank pressure is equal to the highest pressure attained in the air chamber, and this is higher than that in chamber 1 except during an explosion period. Assuming pressure in the tank and the ignition plate, 27, heated, the pump may be started by opening valve 20. The liquid fuel is vaporized in passage 21 and escapes to chamber 1, where it mingles with air and collects until an explosive mixture is formed and exploded. Then the ball check cuts off the fuel supply and the rapidly expanding gases travel down pipe 3, driving the water in pipe 6 into pipe 5 at high velocity and putting the water already in pipe 5 into rapid motion. Thus the water in pipes 6 and 5 constitutes a water piston of small mass. The upward motion of water and gas past the injector nozzles of connection 7 draws in more water from the casing. The uprushing water encounters the splitting nozzle 8 and a large part is deflected outward and upward through the openings shown. The remaining annular core expends its energy in compressing the air in the air chamber around pipe 3. The expanding gases follow the up flowing water piston in pipes 6 and 5 until the pressure in the explosion chamber falls to or below atmospheric. At this point valve 2 opens and air rushes in, down pipe 3 and even into pipes 6 and 5, while water is still flowing in through the nozzles at 7. The rebound of the water piston follows and compresses the fresh air in 1,

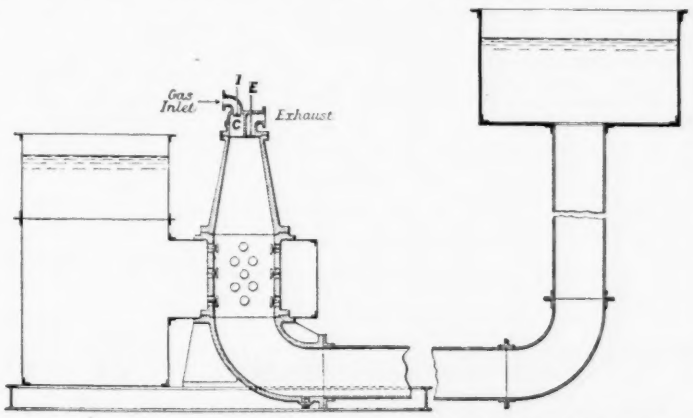


FIG. 2. THE HUMPHREY DIRECT-ACTING EXPLOSION PUMP.
(Reproduced from Engineering News, Dec. 2, 1909.)

while fuel is being admitted and a new cycle starts. Owing to the shape of the top of the splitting nozzle 8, part of the descending water piston is directed outward and upward so that in effect there is a continual upward flow in the casing above the connection 8. On account of the small mass of the water piston, which acts between resilient air cushions, there is practically no disturbance of the water below the pipe 6, through the openings in 7. A large volume of air is induced to enter the upflowing water and a portion finds its way into the air chamber about 3. In some cases, the air in the casing serves as the resilient cushion so that no air chamber is necessary for effective working.

In my patent claims I have held that the principles, functions and effects shown were so novel that the invention is not limited to the forms, proportions and arrangements shown, but is a broad pioneer invention.

In Mr. Humphrey's Dudley Port pump the expansion of the ignited charge drives the water-piston through the play-pipe into the air chamber (not shown in the drawing reproduced in Engineering News, Dec. 2, 1909, but the tank there seen may properly represent the lower portion of the air chamber used). The momentum of the water-piston and the cooling of the gas due to expansion creates a vacuum behind it. At this point a valve opens by atmospheric pressure and admits air to the vacuous space vacated by the water. The first rebound of the water-piston drives out the air and spent gas. A second forward impulse of the water piston is caused by the resilience of a pocket of air trapped in space C and the momentum of the water piston draws in a fresh charge which is compressed on its rebound. Ignition is effected by spark timed to the compression.

These are the two devices then that differ so completely, according to Mr. Humphrey; as he is a consulting engineer he is accustomed to analyze and compare machines so that his statement cannot be the careless word of a layman. Turning to the descriptions themselves, however, we see in the main features, points of identity. (a) Each has an explosion chamber with an expansion extension; in one this extension is long, while in the other it is short. (b) Each uses a water-piston; in one it is short, in the other it is long. (c) Each is provided with an air-chamber into which the water-piston is driven by the expansion of the exploding gas. (d) In each the path of the water-piston is unobstructed by valve or gate, so as to permit the free return of the water-piston. (f) Each has a valve in the explosion chamber opening inwardly to atmospheric pressure for air admission to scavenge. (g) Each has an inlet valve for fuel. (h) Each has an igniter. (i) Each has means to obstruct the return of the suction-water to its source; in one this is provided by the form of the apparatus, while in the other it consists of valves.

They obviously differ in details of construction. But what is more common in practice than that machines of the same character, turned out by different builders, vary from each other in details of construction. Likewise the same make of machine shows variations for different locations or conditions of service.

My pumps have usually been built with 231 cu. ins. (1 gal.) of explosive charge at atmospheric pressure. I adopted this for facility of comparing results. With few exceptions they were U-shaped. I have made them single and duplex (that is two explosion chambers to one air chamber and valve mechanism). Most of them exhausted direct into the atmosphere without entering the water column. I have employed gravity, vacuum and positive displacement to introduce the charge and to exhaust the spent gases. (By positive displacement I mean a simple charging cylinder wholly removed from explosive action to put in the charge at atmospheric pressure or remove the spent gas, this being driven by pressure from the air chamber.) Of the three, and the choice is merely a question of preference, depending on circumstances, I prefer the last as the cycle of the machine is made independent of ignition, or failure to ignite. One charging cylinder serves for any number of pumps in series. It requires so little power that I have even used an ordinary leather bellows to introduce and exhaust the charges. I have one pump (single) in which the spent gas can go into the column or into the atmosphere direct. In this same device it is arranged, as the equivalent of a condensing steam engine, to cool the spent gas to the temperature of the water (for even when expanded below atmospheric pressure there is still sensible heat left in the gas) and the spent and cooled gas can be exhausted direct or sent into the column. In this device also fresh air can be sent into the column or not and with or without the spent gas. All these options are available at will and by the simplest of means.

Mr. Humphrey has never, in exact terms, claimed to have a United States patent. He does not even claim priority of invention anywhere. In fact, his statements about patents are vague and indefinite, and if in the term "foreign countries" the United States is included, that statement seems to need revision.

I, on the contrary, claim pioneership in a new art. I claim to be the *first inventor* of an operative direct-acting explosion pump. I claim to be the *first* to build and operate such a pump with a water piston. I claim further that the pumps designed by Mr. Humphrey which have recently been generally described and illustrated and specifically that one described in the London "Engineering" in the issue of Oct. 15, 1909, are built in accordance with my invention and that they are in fact Smyth pumps, and are within the terms of dozens of claims in my patents, issued and about to issue. For the correctness of these statements and claims there is a superabundance of personal and physical and documentary evidence, both in and out of the United States Patent Office.

Very truly yours,

William H. Smyth.

"Fernwald," Berkeley, Cal., April 18, 1910.

[We have given space to this lengthy discussion in order that our readers may be acquainted with the principal features of a novel motor which has been developed in the United States and about the existence of which general knowledge has resulted only from the publicity given to a similar English motor. This latter (the Humphrey pump), it is now claimed, is really subsequent in conception to that of an American prototype.

This type of explosion motor, as exemplified by both the Humphrey and Smyth pumps, has of course only a very youthful development and its future is obscure. The very feature promoting efficiency—the free piston allowing complete expansion of the "working gas" to outside pressure—seems, for mechanical reasons, to prevent the development of the device as a general prime mover. However, the economic results theoretically indicated and those already attained in trial might cause such ideas to exert some influence on the design of explosion motors, for pumping service at least. It is interesting then

to know whether the ideas involved were originally British or American—or French or German for that matter.—Ed.]

Notes and Queries.

J. S. Calhoun, Jr., Port Royal, S. C., inquires whether anyone has had experience in the construction of a baker's oven of reinforced concrete, to be fired from below. Would such an oven require the usual fire-brick lining for furnace flues and the floor?

A NICE PROBLEM IN MECHANICS.—Our attention was recently called to an interesting problem which arises in connection with the design of the gates at the Pacific end of the Panama Canal and which may arise wherever a canal lock-gate may have fresh water on one side of it and more or less brackish water on the other side.

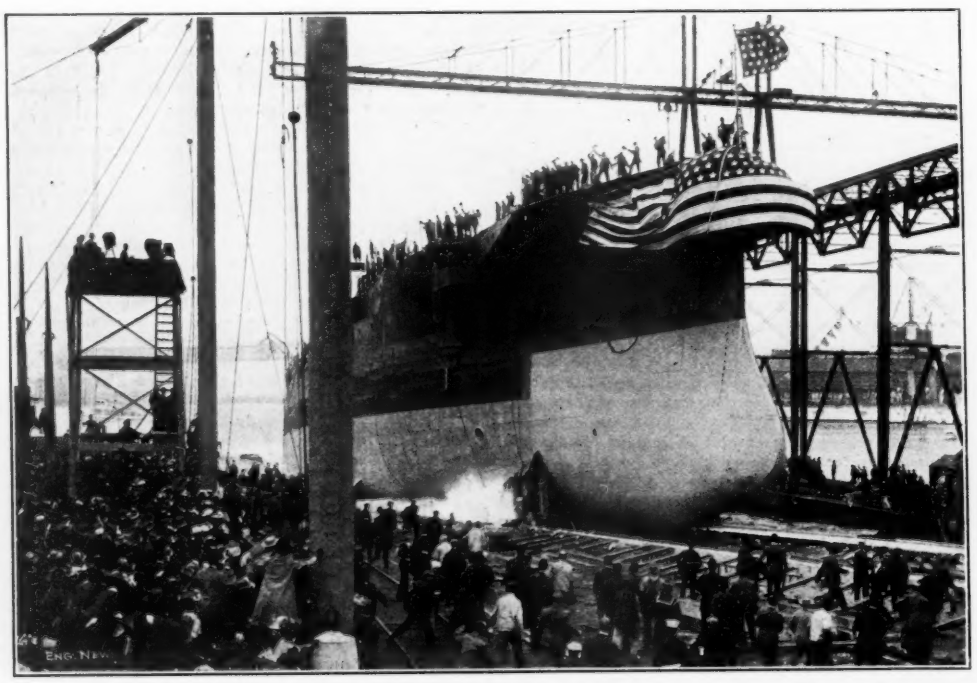
Admittedly the problem is of more interest as a test of an engineer's ability to reason accurately and correctly than as a matter of practical importance in construction, for the leakage through lock gates and culverts and the drawing off of water for locking will tend to constantly dilute the salt water on the ocean side of the gate and make it practically as fresh as the water on the other side.

The problem may easily be stated, however, so as to trap the unwary student. For instance it may be stated that when the gates are closed the water will stand at the same height on the two sides of the gates; but if the water in the lock is fresh and that outside is salt, the pressure against the gates from the outside will then be greater than that from the inside. Is such a condition likely to arise in practice and would you proportion the gate-operating machinery to operate against this excess pressure?

The Launching of the Battleship "Florida."

The battleship "Florida," the latest one of the huge "Dreadnought" type to be floated, was very successfully launched on May 12, at the Brooklyn Navy Yard, where it was built by the Bureau of Construction and Repair and under the direction of Naval Constructor W. J. Baxter.

The "Florida" is 520 ft. long, and on account of lack of adequate dry-dock facilities, was carried farther toward completion before launching than has been customary. It is reported that about 60% of the work on her had been done, the boilers, inside armor, rudder and four propellers being in place. The "Florida" will have a displacement of 21,825 tons (launching displacement 8,800 tons), an engine (turbine) capacity of 28,000 HP., and a crew of 1,010 officers and men. Its main battery will comprise ten 12-in. guns, but in addition there will be 16 5-in. rapid-fire guns, four three-pounders and two one pounders. There will be also two submerged torpedo tubes.



THE LAUNCHING OF THE BATTLESHIP "FLORIDA," AT THE BROOKLYN NAVY YARD.

The launching followed in a general way the standard Atlantic Coast methods (see Engineering News, Dec. 22, 1904), and actually started about 8 a. m., when workmen began to drive the first set of wedges, between the permanent ways and the hull underpinning to take the weight of the hull off the keel blocks. A second and a third set of wedges were driven at about 9 and 10.30, respectively, after which the remaining keel blocks and dog shores were cleared. About 11 o'clock the sandbags, on which the keel near the bow rested, were cut and the hull settled into the cradle. At 11.25 the kingblocks holding the bow cradle to the ways were sawn off and the battleship slid smoothly into the East River. After going out for some 1,500 ft. she was caught by navy tugs and towed back into the yard.

An Association of Highway Engineers and Commissioners.

A new technical association, to be composed of state highway engineers and highway commissioners, was organized at a meeting held at the La Salle Hotel, Chicago, on May 13 and 14. The name adopted is the American Highway League. Its purpose is to study and discuss methods of highway administration, construction and maintenance; also to secure effective cooperation between state highway departments and other state and federal departments interested in highway improvement. There was an attendance of about 20 or 25 at the organization meeting. The President is A. N. Johnson, M. Am. Soc. C. E., State Highway Engineer of Illinois, Springfield, Ill.; Secretary, Thomas H. MacDonald, State Highway Engineer of Iowa, Ames, Ia.

The first session was occupied by the formalities of organizing and a discussion of the proposed constitution. There were no papers, but Mr. A. N. Johnson gave a talk on modern methods of macadam highway improvement (especially in regard to surface treatment with tar, etc.), and this was illustrated by stereoptican views. This started a general discussion in which reference was made to the use of a 4-in. layer of 1:3:5 concrete on a telford base, and covered with a top course of ¾-in. stone well rolled. One member thought that a better pavement could be made by mixing the tar with the stone in advance (so that every stone would be coated) than by applying the tar to the stone already spread upon the road. He expressed the opinion also that if motor traffic could be kept off a water-bound macadam road for 12 months the road could then carry such traffic without disintegrating. Macadam appears to need compacting under regular traffic, which gives it a solidity that cannot be secured by any amount of rolling with a steam roller.

It was pointed out that there are few if any reliable statistics as to the wear and general efficiency of macadam treated in various ways and with various materials, and it was decided to appoint a committee for the purpose of obtaining records of this kind. The work of this committee would be largely in cooperating with and furnishing information to a special committee of the American Society of Civil Engineers on bituminous materials for road construction. The chairman of this special committee is Mr. W. W. Crosby, Chief Engineer of the Maryland Highway Commission, who is also a member of the new society.

Other subjects for discussion included the following: (1) highway bridges, particularly in regard to concrete structures and the work done by local contractors having little experience in this particular line; (2) standardizing specifications for road and bridge work; (3) guarantee bonds for paving and roads, with the view to abandoning the use of such bonds (which are usually impossible of collection or enforcement) or modifying them in such a way that they may be made effective; (4) highway administration, and the remedy of difficulties in the proper expenditure of road and bridge taxes in districts under other than municipal control; (5) the use of convict labor. Another subject was the use of brick paving for highways; this is in use to a considerable extent in Ohio and has been tried elsewhere. One member found that such road construction cost about $17,000 per mile, the brick roadway being 14 ft. wide, on stone or gravel foundation, and the cost included a 12-in. concrete curb on each side.

On the second day of the meeting a visit was paid to the state prison at Joliet, where there is a quarry and a stone crushing and screening plant operated by convict labor. Much of this stone is used for road work.

Some Temperature Readings in Setting Concrete.

By R. H. BROWN.*

During the construction of the pulp and power development of the Hollingsworth & Whitney Co., at Madison, Me., on the Kennebec River, 1908-09, some tests were made on the interior temperature of concrete during its progress of setting. The massive canal walls offered an ideal place for the tests, as the recording thermometer could be placed in the center far enough from either exposed side of the wall as to be unaffected by the changing temperature of the air. The forms were not removed during the first month of the test, which also assisted materially.

A 3-in. wrought-iron pipe, fitted with a plug and made just long enough to project above a day's run, was set in the concrete. As fast as the concrete rose another length was screwed on. In this pipe there was placed a self-recording thermometer, and upon the outside of the forms another was hung for reading outside temperature at the same place and time.

The concrete mixture was made in the proportion of 1:3:5. All materials were warmed before being mixed, and the temperature of a batch just previous to placing was about 70°. All readings were taken at 7 a. m.

The concrete was placed Jan. 18, the outside temperature being — 10° F. Proper precautions were taken to prevent freezing while the mixture was getting its set. This was done by covering forms with canvas and turning on just enough steam to keep the frost out. The readings were the maximum and minimum temperatures for 24 hours.

As can be seen by the accompanying table, the rise in temperature is rapid until it reaches 119°, this temperature being reached in nine days. After this a gradual decline takes place until on May 4 it reached 49°. This temperature maintained for one week, when readings

*Construction Engineer, Great Northern Paper Co., Madison, Me.

TEMPERATURE READINGS IN CONCRETE.

Date.	Depth in concrete, ft.	Temperature in air, deg.	Temperature in pipe, deg.	Date.	Depth in concrete, ft.	Temperature in air, deg.	Temperature in pipe, deg.
Jan. 19-09	3	—18	91	Mar. 9-09	37.0	—1	75
" 20 "	3	— 2	94	" 10 "	37.0	29	74
" 21 "	7.5	14	96	" 11 "	37.0	32	73
" 22 "	15.5	34	98	" 12 "	37.0	20	73
" 23 "	15.5	39	106	" 13 "	37.0	11	72
" 24 "	15.5	20	110	" 14 "	37.0	6	72
" 25 "	15.5	15	111	" 15 "	37.0	15	71
" 26 "	15.5	18	113	" 16 "	37.0	3	70
" 27 "	26.25	— 2	119	" 17 "	37.0	22	69
" 28 "	35.0	18	119	" 18 "	37.0	21	68
" 29 "	35.0	14	116	" 19 "	37.0	19	67
" 30 "	37.0	21	116	" 20 "	37.0	19	66
" 31 "	37.0	20	113	" 22 "	37.0	19	64
Feb. 1 "	37.0	0	113	" 23 "	37.0	22	64
" 2 "	37.0	— 5	110	" 24 "	37.0	14	64
" 3 "	37.0	—10	109	" 25 "	37.0	20	63
" 4 "	37.0	—11	113	" 26 "	37.0	36	62
" 5 "	37.0	23	114	" 27 "	37.0	32	62
" 6 "	37.0	28	106	" 28 "	37.0	32	62
" 7 "	37.0	17	104	" 29 "	37.0	36	61
" 8 "	37.0	6	101	" 30 "	37.0	35	61
" 9 "	37.0	— 4	98	" 31 "	37.0	28	60
" 10 "	37.0	9	96	Apr. 1 "	37.0	26	60
" 11 "	37.0	25	99	" 2 "	37.0	16	59
" 12 "	37.0	4	100	" 3 "	37.0	23	58
" 13 "	37.0	20	99	" 4 "	37.0	33	57
" 14 "	37.0	18	106	" 5 "	37.0	26	57
" 15 "	37.0	11	94	" 6 "	37.0	32	57
" 16 "	37.0	14	93	" 7 "	37.0	36	57
" 17 "	37.0	12	92	" 8 "	37.0	37	56
" 18 "	37.0	7	92	" 9 "	37.0	30	56
" 19 "	37.0	— 8	91	" 10 "	37.0	28	56
" 20 "	37.0	17	90	" 12 "	37.0	16	55
" 21 "	37.0	22	88	" 13 "	37.0	30	55
" 22 "	37.0	4	88	" 14 "	37.0	47	55
" 23 "	37.0	16	88	" 15 "	37.0	36	54
" 24 "	37.0	32	86	" 16 "	37.0	34	53
" 25 "	37.0	34	86	" 17 "	37.0	34	53
" 26 "	37.0	6	85	" 18 "	37.0	32	53
" 27 "	37.0	5	84	" 19 "	37.0	38	52
" 28 "	37.0	3	83	" 20 "	37.0	38	52
Mar. 1 "	37.0	— 6	82	" 21 "	37.0	28	52
" 2 "	37.0	6	81	" 22 "	37.0	36	52
" 3 "	37.0	1	80	" 23 "	37.0	34	52
" 4 "	37.0	15	79	" 24 "	37.0	28	52
" 5 "	37.0	25	79	" 25 "	37.0	21	52
" 6 "	37.0	16	78	" 26 "	37.0	32	52
" 7 "	37.0	2	77	" 28 "	37.0	33	50
" 8 "	37.0	11	75	May 4 "	37.0	41	49

were discontinued. It is quite evident from the variation of the temperature of the air that the thermometer in the pipe was unaffected. The apparent discrepancy of the temperature on Feb. 4-5 is probably due to inaccurate reading by observer.

Notes from Engineering Schools.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—The first conferring of the degree of Doctor of Engineering, in course, at this school, will occur at the 1910 commencement. The Institute has heretofore given very many second degrees for advanced study in engineering, and a few degrees of Doctor of Philosophy to students who have pursued advanced study in chemistry and other more general sciences, but it has not heretofore conferred a Doctor's degree on a student for extended advanced study of engineering.

UNIVERSITY OF WISCONSIN.—The formal opening of the new Forest-Products Laboratory will occur on June 4, it is announced. This laboratory is to aid, by means of experiments and demonstrations, in lessening present waste in the use of wood. The laboratory will be prepared to make tests on the strength and other properties of wood, to investigate processes of treating timber for preventing destruction by decay and other causes, to study the saving of by-products in wood waste by distillation processes, to examine the fiber of various woods for paper and other purposes, and to determine the relation of the microscopic structure of wood to its characteristics and properties. Facilities are at hand for almost any kind of test on wood that practical conditions may require. It is hoped and expected that lumber and wood industries will make large practical use of this laboratory in finding methods of reducing waste. It is announced that already many such concerns have proposed experiments and supplied much test material, which is awaiting attention.

The State of Wisconsin has erected, for the laboratory, a new building on the university campus, and will provide light, heat and power. The U. S. Forest Service has supplied the equipment and apparatus and will maintain the force of 35 to 40 persons required to carry on the work. Through this arrangement the United States has secured, it is claimed, the largest and best equipped wood-testing laboratory in the world.

It is planned to make the opening an important event. There will be one session at which addresses will be delivered. Following this, a systematic inspection of the laboratory and its equipment will be made, with demonstration work in progress. An effort will be made to have a special train of sleeping cars run from Chicago to Madison on the evening of June 3, and back to Chicago on the evening of June 4, so that those who make use of this train will require no hotel accommodations at Madison.

A BATTERY OF FIVE BOILERS EXPLODED May 15 at the plant of the Diamond Coal & Coke Co., at Chewtown, Washington Co., Pa. The boiler-house was wrecked and the three men who were in it were killed. Three neighboring houses were destroyed by fire started by the explosion. Close to the boiler plant were about a dozen dwelling-houses and in these several persons were injured by flying wreckage.

SEVEN BOILERS EXPLODED IN THE PLANT of the American Sheet & Tin Plate Co. at Canton, Ohio, May 17. Thirteen men were killed and 30 others seriously injured. Many of the injured are not expected to survive. The interior of the building, according to reports, was completely wrecked, leaving only portions of the outer walls standing. The ruins took fire but the flames were quickly extinguished. The fireman and engineer were both in the boiler-room at the time of the explosion and both were killed. None of those who survive were aware of any trouble with the boilers. Press reports quote one survivor as saying there were three distinct explosions in quick succession. About 100 men were at work in the plant when the accident took place and only about twelve of these escaped without some injury. The violence of the explosion is evidenced by the report that one man's body was blown through the two opposite walls of a frame house 700 ft. from the plant.

A COAL MINE EXPLOSION IN ENGLAND in the Wellington coal mine at Whitehaven, May 12, entombed 137 miners, all of whom have probably perished. The mine, which extends a considerable distance out under the sea, was wrecked and set on fire. The rescuers were soon obliged to abandon their efforts and the mouth of the pit was sealed May 13 to smother the fire.

POWDER AND DYNAMITE EXPLOSIONS reported last week were unusually numerous. A nitroglycerin magazine exploded May 10 near Burgettstown, Pa. One man, an oil-well shooter, was killed and ten other persons were injured. The magazine was only three-quarters of a mile from Burgettstown and practically every window in that place was shattered. About one ton of nitroglycerin exploded.

A temporary powder magazine at a stone quarry at Trimmer, Ind., six miles west of Logansport, exploded May 12. About 300 lbs. of blasting powder were involved. Many houses in Trimmer were heavily damaged. The man in charge of the magazine is believed to have been killed, although no trace of his body was found.

A car of dynamite exploded at the Du Pont powder works, 15 miles south of Tacoma, Wash., May 12, and two men were killed. The shock of the explosion was felt at Tacoma, but details of the damage at the powder works are not available. The explosion is ascribed to the derailment of the car.

A keg of explosive blew up May 13 at the factory of the Pittsburg Cap Pistol Co. on Main St., Homestead Park, Pittsburg, Pa. The explosion occurred shortly after 5 o'clock in the morning. The night foreman was killed and a young boy at work in the factory was injured. The plant was being worked night and day to fill July 4th orders for caps and toy pistols. The windows of dwellings within two blocks of the factory were broken.

A MISSISSIPPI RIVER STEAMER SANK May 11 at Glen Park, Mo., 24 miles below St. Louis. The boat ran aground on a limestone ledge at a bend and twelve persons fell into the water and were drowned while trying to get to shore on the gang plank. The boat, the "Saltillo," is the property of the St. Louis & Tennessee River Packet Co. and has a wooden hull. She was proceeding downstream at about 15 miles per hour on the evening of the accident. The river was high with more than the ordinary current.

Above Glen Park is a long stretch of practically straight channel terminating in a rather abrupt curve at the point where the wreck occurred. Just before reaching this bend, the steamer entered the smoke cloud from a lime kiln on the bank. The pilot's view of the shore was obscured and he decreased the boat's speed. It seems probable that, as a result of the high current, the steamer continued ahead at a higher speed than the pilot estimated. Upon emerging from the smoke, the pilot found his craft close upon the bank at the bend. He at once ordered the engine reversed, but the current carried the boat onto a limestone reef within a few feet of the shore.

She struck on the ledge at a point about 6 ft. from the bow and a hole some 25 ft. long was torn in her starboard side. The pilot ordered full speed ahead as soon as she struck to hold her bow to the shore, but the current swung the stern around and the hull filled rapidly so that she sank within five minutes. The upper decks of the boat remained out of water on the side toward shore. The top of the boat leaned away from the bank at an angle of about 45°.

As soon as the vessel grounded, the captain ordered out the gang plank and urged the passengers to hasten ashore. The plank, or landing stage, was run out almost to the river bank and 14 persons were on it ready to land when the boat swung out from shore. The stage fouled the branch of a tree and its supports gave way so that every one of the 14 was either knocked or dropped into the swift current. One of the men on the stage was thrown to the bank and one other reached the shore by swimming. Later all the people remaining on the boat were taken ashore by means of planks. Most of the baggage and freight was also recovered.

Three of the bodies of the twelve persons drowned had been recovered up to Friday afternoon, May 13. The coroner's verdict was "death from unavoidable accident." A Federal investigation of the accident is being conducted by U. S. Steamboat Inspector, J. J. Dunn.

THE ATLANTIC LINER "MINNEHAHA," which went aground on the Scilly Islands on April 18, as reported in Engineering News of April 21, 1910, p. 478, has been floated and has proceeded under her own steam to a safe harbor in the islands.

THE BEAVER BRIDGE WAS OPENED TO TRAFFIC on May 14, 1910. A load test had been made earlier in the week. As construction work on the piers was started in Spring 1908, the entire structure was built in just two years. The new bridge gives the Pittsburg & Lake Erie Ry. a double-track crossing over the Ohio River at Beaver, Pa., in place of the old single-track bridge, which will now be taken down.

AN INEXPERIENCED AVIATOR was killed at Lyons, France, during a small aviation meet, on May 13. The machine fouled with a 25-ft. pole marking a turning point. It is reported that the machine was wrecked and that the pole fell on the aviator fracturing his skull and spine.

AN ALTITUDE OF 20,600 FT. was reached by Messrs. A. H. Forbes and J. C. Yates, of New York City, on May 10 in the balloon "Viking." The ascent was made from Quincy, Ill., at 6.55 p. m., May 9, in an attempt to secure a long-distance record. This attempt failed as the balloon made a semi-circle over Illinois, Missouri, Indiana and Kentucky. The altitude of 20,600 ft. was reached on the morning of May 10 and the occupants of the bucket became so benumbed with cold that they lost control of the balloon. It is reported that in the later descent an accident to the basket caused the rip seams

to be opened when the balloon was about 300 ft. above the earth. In the resultant fall the balloon was partially wrecked, but the aeronauts were not seriously injured.

AN AVIATION MEET will be held on Long Island, New York, in October, at which, it is announced, contests will be held for the world championship, which was won by Glen H. Curtiss at Rheims, France, in 1909.

By agreement with the Wright Company, controlling the patents of Orville and Wilbur Wright, which patents are claimed to cover parts of practically all present aeroplanes, all foreign aviators will be allowed to operate their machines. The company is to receive a percentage of the net profits for not enforcing the injunction recently obtained against such machines.

The privilege of holding the meeting will be awarded to the highest bidder, but the entire meeting will be controlled by the Aero Club of America as the representative of the International Aeronautic Federation. The meeting will be held under the rules and regulations of this federation.

A SLIGHT BRIDGE ACCIDENT occurred recently to one of the truss spans of the Sangamon St. viaduct, Chicago, crossing the Chicago & Northwestern Ry. Owing to the increased weight of the new cars of the street railways repairs and reinforcement of several of the viaducts have been made necessary, and were in progress at this point. Some bearing stones on the masonry pier which were in bad condition were being removed, to be replaced by concrete blocks. At the time of the accident one corner of the span was supported by timber shores while the new bearing block on bridge seat was being prepared. The shores were not in good condition and were partly rotten. As a heavy passenger car and a heavily loaded construction car passed this end of the bridge at the same time, the defective timbers broke and the corner of the span settled about 18 ins. A few top laterals were broken, the end hanger (attached to the hip of the end post) was bent by compression, and some of the lacing on the inner side of the end post was distorted, twisting off the rivet heads. As the cars were moving at a fair rate of speed they passed beyond the danger point as the span settled, so that the passengers experienced only a slight jolt. New shoring was at once put in place, and the corner of the truss jacked up to its proper position.

A BREAK IN THE ERIE CANAL in Syracuse, N. Y., on May 9, threatened to undermine the nearby railway fill of the New York Central and Lackawanna railways. Just west of the railway station in the city there was completed last winter a sewer under the railway and the canal, both of which are on a fill at this point. The portion under the railway was built in tunnel, but that under the canal was in open cut, a well puddled back-fill being made. Concrete cut-off walls were then sunk on either side of the canal to a distance some feet below the canal bottom, which is about 18 ft. above the top of the sewer. A concrete cut-off wall was also sunk between the canal and railway all the way to the top of the sewer. It is supposed that a leak started in the side of the canal bottom toward the railway at the time of the spring refilling of the canal and, notwithstanding the puddle back-fill, the water worked its way under the cut-off walls into the back-fill around the tunnel under the railway, and caused the washout.

Fortunately, the leak was discovered before the railway embankment had settled to a dangerous degree, and a coffer-dam around the leak was soon built and further washing prevented. This is a short level in the canal, so that it was soon filled after the repairs were made and the opening of the canal on May 16, as required by law, was not interfered with.

PANAMA CANAL WORK IN APRIL.—The total excavation during April, 1910, was 2,632,468 cu. yds. (place measurement), which is about 400,000 cu. yds. less than the March output, with the same number of working days (26) but an increased rainfall (5.08 ins., against 3.70 ins. in March). Concrete work amounted to 96,120 cu. yds. laid. Fill placed in the dams totaled 549,271 cu. yds.

THE SIXTH YEAR'S WORK AT PANAMA.—The early part of May, 1910, saw the beginning of the seventh year of work by the American forces on the Panama Canal. The American excavation during the six years amounts to 105,888,072 cu. yds., of which 32,672,565 cu. yds. was done in the sixth year, 1909-10. About 68,000,000 cu. yds. remains to be excavated, of which something over half is steam-shovel work, the rest dredging. The total amount taken out of the Culebra Cut during the six years was 46,913,450 cu. yds., about 15,000,000 cu. yds. having been taken out in the sixth year. The Gatun dam is progressing well, the west half having been closed recently (as noted in this column two weeks ago) and thereby the impounding of the Chagres begun, while in the east half of the dam the hydraulic fill between the rock embankments on either edge has been carried up to 53 ft. above sea-level. The total fill in the dam will amount to ten million cubic yards, and about one-third of this quantity has been placed. Gatun Locks concreting was begun during the past year, and by April, 1910 a monthly product of over 60,000 cu. yds. placed had been attained. The total concrete so far placed in Gatun Locks is 350,000 cu. yds., out of 2,200,000 cu. yds. total. The Pedro Miguel locks were started a little later, and by May, 1910, a total of 107,470 cu. yds. concrete had been placed, of which about 25,000 cu. yds. was done in April; the Pedro Miguel total will be 807,000 cu. yds. At Miraflores locks the concreting will amount to 1,505,000 cu. yds. (After "Canal Record" of May 4, 1910).

Personals.

Mr. George Rettig has been appointed Superintendent of City Forestry of Cleveland, Ohio.

Mr. Chas. W. King, Assistant Superintendent of the Utah lines of the Denver & Rio Grande R. R., with headquarters at Salt Lake City, has resigned and the position has been abolished.

Mr. Geo. S. McKee, who is to retire June 1 as Superintendent of Motive Power and Car Equipment of the Mobile & Ohio R. R., has been presented with a gold watch by the employees of his departments.

Mr. Alfred Beaver has resigned his position as Division Superintendent of the Northern Pacific Ry. at Spokane, Wash., and has been succeeded by Mr. J. M. Rapelje, formerly Division Superintendent at Missoula, Mont.

Mr. S. T. Fulton, formerly assistant to the President of the Chicago, Rock Island & Pacific Ry., has succeeded Mr. J. L. Woods, resigned, in the sales department of the Railway Steel Spring Co., with headquarters at Chicago, Ill.

Mr. Bernard J. Mullaney, formerly Secretary to Mayor Busse, of Chicago, has been appointed Commissioner of Public Works of that city to succeed Mr. John J. Hanberg, resigned. One of Mr. Mullaney's first official acts in his new position was to discharge Mr. Wm. E. Quinn, Superintendent of Sewers.

Mr. R. B. Kendig, Mechanical Engineer of the Lake Shore & Michigan Southern Ry., has been made General Mechanical Engineer of the New York Central Lines to succeed Mr. F. M. Whyte, whose resignation was noted in our last week's issue. Mr. A. R. Ayers, Assistant Division Master Mechanic of the Lake Shore at Elkhart, Ind., has been promoted to succeed Mr. Kendig.

Obituary.

George Aitchison, Past-President of the Royal Institute of British Architects, died May 16 in London, England.

Michael Elmore, contractor, died May 11 at his home near White Plains, N. Y., aged 57 years. He was President of the Elmore & Hamilton Co., which has the contract for sections 15 and 53 of the Catskill aqueduct.

John Edwards McKay, M. Am. Soc. C. E., died May 13 at his home in White Plains, N. Y., after a long illness. Mr. McKay was 74 years old. He had been employed for many years in the water department of New York City.

J. J. King, General Superintendent of the San Antonio Traction Co., died May 9 at his home in San Antonio, Tex., aged 38 years. His death resulted from an attack of typhoid pneumonia. Mr. King had been connected with the San Antonio Traction Co. for about 15 years, and all the street railway lines in the city were built under his direction.

Rear-Admiral Andrew J. Kiersted, U. S. N., retired, died May 11 at his home in Philadelphia, Pa. He was born in Mathews Co., Va., in 1832, entered the navy in 1856 as an assistant engineer and became a chief engineer in 1861. He was in three different years a member of the Naval Examining Board and was President of the board in 1875. In 1881-82 he was Fleet Engineer of the North Atlantic Squadron. He retired in December, 1904.

William Huggins, an English astronomer, died May 14 in London, England. He was born in London in 1824, and at the time of his death had been actively engaged in astronomical research for more than 50 years. He was the first to apply the Doppler principle to the measurement of stellar velocities and took a prominent part in the development of spectroscopic astronomy. At various times he had been President of the Royal Astronomical Society, the British Association for the Advancement of Science and the Royal Society.

James Wallace Van Cleave, Past-President of the National Association of Manufacturers, died May 15 at St. Louis, Mo. Mr. Van Cleave was born in Marion Co., Ky., in 1849. After the conclusion of the Civil War, during which he served in the Confederate Army, he entered the stove making business and eventually became President of the Buck's Stove & Range Co. He attained distinction by his persistent opposition to what he has termed "the follies and vices of labor unions and the tyrannical and unpatriotic practices of certain captains of industry."

Engineering Societies.

COMING MEETINGS.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 23-26. Annual meeting at Chicago, Ill. Secy., D. B. Sebastian, 327 La Salle Station, Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 23-28. Annual meeting at St. Louis, Mo. Secy., T. C. Martin, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 31-June 3. Spring meeting at Atlantic City, N. J. Secy., Calvin W. Rice, 29 West 39th St., New York City.

ENGINEERS' SOCIETY OF PENNSYLVANIA.
June 1-4. Annual convention at Harrisburg, Pa. Secy., E. R. Dasher, Gilbert Bldg., Harrisburg, Pa.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 7-9. Annual convention at Detroit, Mich. Secy., Richard Moldenke, Watchung, N. J.

MASTER CAR BUILDERS' ASSOCIATION.
June 15-17. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 20-22. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 21-24. Annual convention at Chicago, Ill. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 22-24. Semi-annual meeting at Niagara Falls, N. Y. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 23-25. Annual meeting at Madison, Wis. Secy., Henry H. Norris, Cornell University, Ithaca, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 27-30. Annual convention at Jefferson, N. H. Secy., R. W. Pope, 33 West 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 28-July 2. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
June 30-July 1. Semi-annual meeting at St. Louis, Mo. Secy., W. M. Mackay, P. O. Box 1818, New York City.

KANSAS STATE MUNICIPAL LEAGUE.—A meeting is to be held in Wichita, Kan., May 18-19. The program includes an address by Mr. David Heineman, President of the League of American Municipalities, and an illustrated lecture on American and European sewage disposal works by Mr. R. E. McDonnell, M. Am. Soc. C. E.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Two leading subjects for discusion at the meeting at Madison, Wis., June 23-25, will be (1) efficiency in education and (2) improvements in methods of teaching calculus so as to make it more generally available as a practical tool for engineering graduates.

It is proposed to arrange a symposium on the first subject, efficiency in education, which will be discussed under the following heads:

1. Organizing and systematizing the work of the students; methods of arousing their interest and of encouraging them to make the best use of their time and opportunities.
2. Organizing and systematizing the work of instructors so that each department of study shall have its due share of the student's time and energy, and no more.
3. Conduct of recitations and examinations, control of outside reading, study, and problem work so as to secure the best results.
4. Improvement of lecture instruction; use and abuse of lectures; utilization of syllabi, indices, bibliography and encouragement of outside reading; lecture illustration, experiments, use of blackboard, models, diagrams, lantern slides; economy of student's time and energy and methods of securing his attention in lecture period. Advantages and disadvantages of printed lecture notes.
5. Relative advantages and disadvantages of lectures and recitations; subjects suited to one or the other method of instruction; limitations of each method.
6. Improvement of laboratory instruction; in the preliminary preparation of students, in the supervision of laboratory work, in the character of the work required, in facilities for work, in reports of work done, and deductions therefrom.
7. Improvements in shop work instruction; relative importance of manual training and study of actual shop practice; should manual training form any part of the curriculum?
8. Organizations of vacation work; assignment of time to different subjects; utilization of time to best advantage; class work versus individual study; should students be encouraged to seek remunerative employment by allowing academic credit for such work?
9. Graduation theses; in what ways can these be made more useful?
10. Original investigation; is it desirable to have the graduation theses involve original investigation by the students?

The second subject, improvements in methods of teaching calculus, will come up in connection with the discussion of the report of the committee on mathematical instruction. A circular letter has been issued soliciting answers to questions designed to bring out estimates and opinions as to the success of present methods at various schools and suggestions for increasing the efficacy of instruction in this line.